VOLUME 72 NUMBER

INDIAN FORESTER

JANUARY, 1946

THE VICEROY'S VISIT TO THE FOREST RESEARCH INSTITUTE AND COLLEGES

During a short tour of three and a half days in Dehra Dun His Excellency Lord Wavell found time to pay a visit to the Forest Research Institute and Colleges. His Excellency's programme was a very full one and it was not possible for him to spare more than an hour at New Forest. All that could be done was to show Lord Wavell some of the work done in the Utilisation Branch and attempt to give him an idea of the organisation of the institute and the type of problems dealt with in the other branches.

Post-war plans for the reconstruction, development and extension of India's forests, after six years of war, has made it necessary to expand the Indian Forest College and the Indian Forest Ranger College to meet the very large demand from Provinces and Indian States for trained forest officers and forest rangers.

The more extensive use of India's timbers and other forest products, soil conservation and the prevention of erosion will necessarily involve a corresponding expansion of the forest research. If the best use is to be made of the forest wealth of India and the Forest Research Institute is to take its rightful place in the post-war years, its potential capacity should be developed to the fullest possible extent, as soon as possible, since research should precede the execution of post-war plans.

The institute, like the colleges, is on the threshold of a period of increased activity and His Excellency's visit was most welcome, and a grateful acknowledgement is due to him for his keen and sympathetic interest in the Forest Research Institute and Colleges. It is to be hoped that, in the not too far distant future, it will be possible for His Excellency the Viceroy to honour the Forest Research Institute and Colleges with another visit of a longer duration.

GRAZING AND PASTURE RESEARCH IN INDIA*

BY THE CENTRAL SILVICULTURIST.

(*Forest Research Institute and Colleges, Dehra Dun*).

The resolution on item 11 of the 1939 silviculture conference defined the scope of research under this head. The problems with which we are faced were divided into two classes:—

(*a*) Those which involve indirect methods of utilisation and improvement, whether by hay harvesting, silage and drying or by manuring, burning, introduction of useful exotics or other forms of cultivation.

(*b*) Those which are concerned with direct utilisation and improvement of the pasture through regulated grazing.

(a) Indirect Methods of Utilisation

The only work done in India, since the last silviculture conference, with the general object of determining and standardising experimental design and layout for problems of the first kind are the Nagpur pasture investigations of 1939 & 1940. It is expected that the province concerned will later publish a full account of the investigations but for the information of the present conference a brief summary of the investigation is given as the silviculture branch of the F.R.I. did all the computing work.

The Nagpur Pasture Investigation of 1939

Object of the investigation.—The object of this preliminary investigation was to determine:—

(*i*) the best size of the ultimate sampling unit.

(*ii*) the number of such sampling units adequately to represent the growth in each of the plots, and

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* Paper read at the 6th Silvicultural Conference, Dehra Dun (1945), on item 8—Grazing and Pasture Research.

(iii) the number of plots per treatment, or replications, to yield a valid estimate of experimental error.

Data & the methods of their collection.—An area of 10 acres of *charagah* (pasture land) and 2.5 acres of *bir* (grass reserve) near Nagpur was fenced and divided into 125 plots of one-tenth of an acre each. Five quadrats each 10 links ×10 links (=.001 acre) were selected at random in each plot for sampling the growth. As only one size of ultimate sampling unit was used the investigation could not give indications on object (*i*), the best size of sampling units.

Observations of the stocking of grass were recorded both by green weight and by ocular-estimates of the density of stocking (very thick =100%; thick=75% to under 100%; sparse= 50% to under 75%, very sparse under 50%; for three different kinds of herbage, *viz.*,—

(*a*) important fodder grasses and legumes,
(*b*) less important fodder grasses, and
(*c*) non-fodder grasses.

The average yields per acre of these different kinds of herbage were found to be as follows:—

Table 1.—*Yield per acre of the various kinds of herbage found in the Nagpur pasture plots.*

Species	Average yield per acre of various species growing in mixture.	
	Green lbs.	Dry lbs.
(*a*) Important fodder grasses and legumes		
(*i*) *Sheda* (*Schima nervosum*)	26	16
(*ii*) *Mushan* (*Iseilma laxum*)	292	141
(*iii*) *Lahan marvel* (*Dicanthium annulatum*)	107	55
(*iv*) *Mothi marvel* (*Dicanthium caricosum*)	97	34
(*v*) *Legumes* (*Alyslcarpus rugosus Indigofere linifolia*) ..	114	49
(*b*) Less important fodder grasses		
(*vi*) *Kusal* (*Heteropogon contortus*)	304	163
(*vii*) *Ghonad* (*Themeda quadrivalvis*)	41	20
(*viii*) *Diwartan* (*Andropogon pumilus*)	575	290
(*ix*) *Gadhasheda* (*Chrysopogon montanus*)	276	141
(c) Non-fodder grasses		
(*x*) All remaining	652	293
Total per acre ..	2,466	1,202

The co-efficients of variability between the quadrats were found to be as follows:—

Table 2.—*Co-efficients of variability between quadrats for the different kinds of grasses.*

Types of grasses	Co-efficients of variability.	
	Ocular estimate	Green weight
(*a*) ..	75.7	76.3
(*b*) ..	66.3	68.8
(*c*) ..	89.2	88.1

Conclusions

(1) *Determination of the size of the sampling unit.*

This could not be found as only one size of sampling unit, *i.e.*, 10×10 links, was tried.

(2) *Determination of the number of sampling units.*

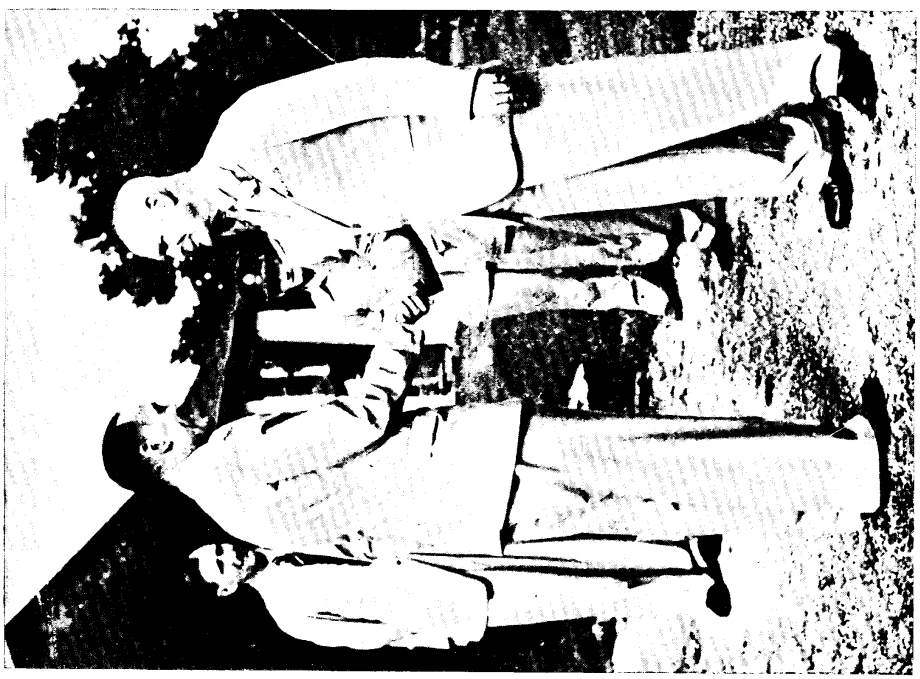
The minimum number of sampling units was found to be 35, for a standard error of 15% of the mean.

It is interesting to note that the co-efficient of variability between quadrats was found to be nearly the same for both ocular estimates and actual green weights of the herbage (vide table 2 above). The correlation co-efficients between the ocular estimates and the actual weights also showed a high degree of significance. It seems, therefore, that under the conditions of the Nagpur experiment ocular estimates alone may be sufficiently accurate for determining treatment effects.

(3) *Determination of the number of plots required per treatment.*

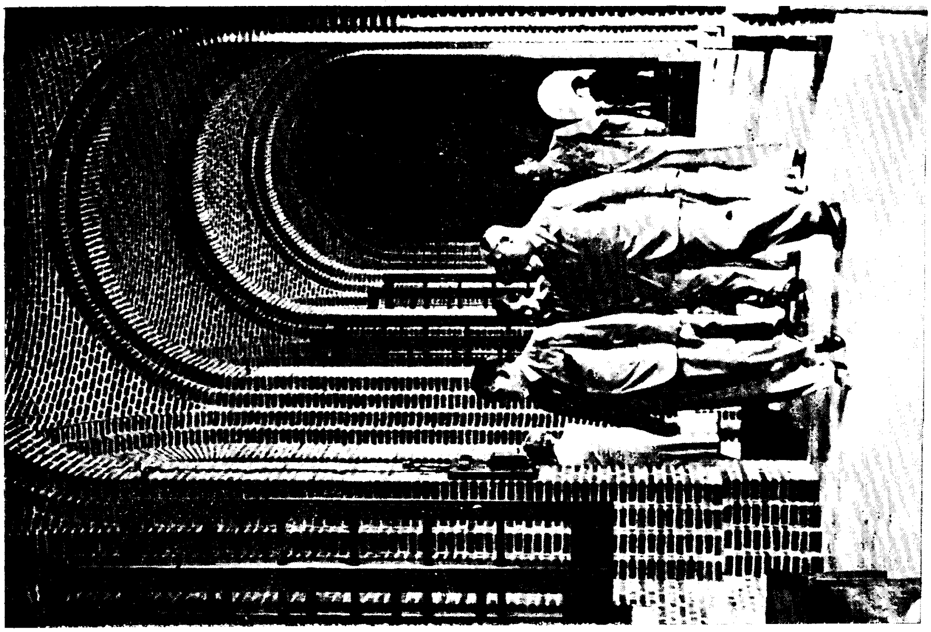
The number of plots was found to be in the neighbourhood of 200. This would be unwieldy in practice owing to the design of the experiment, the sampling error in this investigation was very great, large numbers of plots (200 per treatment) and sampling units (35 per plot

Fig. I



His Excellency Lord Wavell saying good-bye after visiting the Utilization Branch, Forest Research Institute and Colleges, Dehra Dun.

Fig. II

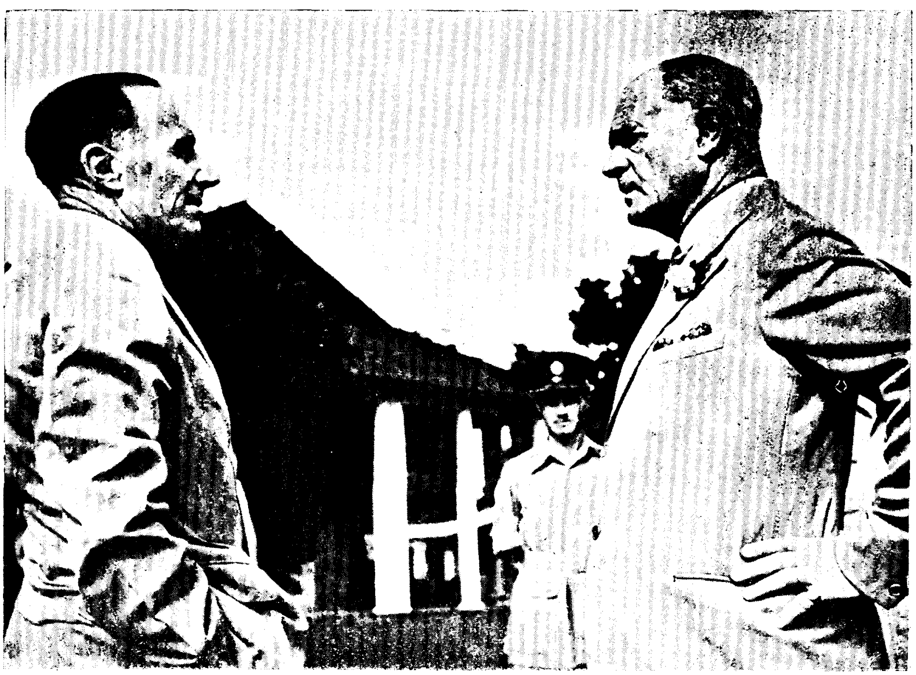


A view of the South Corridor of the main building. His Excellency with the President and his Director of Education.

Fig. III

H. E. Lord Wavell being shown the site plan for the new Indian Forest Ranger College at the New Forest.

Fig. IV



H. E. Lord Wavell and the President. Forest Research Institute and Colleges.

were found to be necessary in order to obtain reasonable accuracy. This defect was sought to be remedied in the design for the 1940 investigation.

The Nagpur Pasture Investigation of 1940

The objects of the 1940 investigation were the same as those of the 1939 investigation. The results of the 1939 work indicated a strong correlation between ocular estimates of stocking and the green weights of the herbage. It was decided to take advantage of this fact, and this resulted in a great saving of time and expense. It was also decided to divide each tenth acre plot into 100 parts and to have three sizes of sampling units for comparison.

Description of the investigation.—The investigation was again conducted in the two adjacent areas near Nagpur, known as the *charagah* (10 acres) and the *bir* (2.5 acres). Both the areas were fenced and grazing was not permitted. The area was divided into plots of one square chain each. There were 100 plots in the *charagah* and 25 in the *bir*. Each plot was again divided into 100 parts of .001 acre each, for purposes of sampling and 25 samples per plot were selected at random. For recording the herbage, each part was dealt with as if made up of three sizes or sections A, B & C, A being 1-9th of .001 acre, B 4-9th of .001 acre, and C .001 acre.

The heights and percentages of the herbage were recorded for (*a*) important fodder grasses and legumes, (*b*) less important grasses and (*c*) non-fodder species. The percentage of stocking was calculated from the records of the density of stocking and the percentage of the various types of herbage, both of which figures were based on ocular estimates.

Note.—Before starting the experiment it was arbitrarily decided that in such investigations if the standard error was within 15% of the mean, sufficient accuracy would be attained.

It was also similarly decided that under the above conditions differences between treatment means, of 10% or more would be sufficient to establish the effect of treatments.

Calculation of the data.—This consisted of calculating the percentage of stocking, for the three types of herbage for the three sections A, B & C of the sampling units.

The mean percentage of stocking was next determined as well as the sampling and plot errors. The results are tabulated below.

Table 3.—*Percentage of stocking of the various types of herbage.*

Type of herbage	Mean percentage of stocking as calculated from the three sections, A, B & C.		
	A=1/9th of ·001 acre	B=4/9th of .001 acre	C=.001 acre.
(*a*) Important fodder grasses and legumes	22.3	22.0	20.5
(*b*) Less important fodder grasses ..	23.0	22.7	20.8
(*c*) Non-fodder species	22.0	22.1	24.7

Table 4.—*Sampling & plot errors as calculated for the 3 types of herbage (stated as percentage of the mean).*

Type of herbage	Plot error			Sampling error			Total error		
	A	B	C	A	B	C	A	B	C
(*a*) Important fodder grasses and legumes ..	12.8	13.0	13.4	11.8	12.4	14.7	17.4	18.0	19.0
(*b*) Less important fodder grasses ..	10.8	11.1	11.4	12.8	13.5	16.0	16.7	17.5	19.5
(c) Non-fodder species ..	9.2	9.2	9.7	13.6	14.2	14.5	16.4	13.9	17.4

From the co-efficient of variability of the mean for the various types of herbage it is now possible to calculate the minimum number of sampling units that are considered adequate, with a standard error of 15 per cent. of the mean as the limit, from the simple relation.

Number of sampling units

$$=\left(\frac{\text{standard deviation}}{15}\right)^2.$$

This is set forth below.

Table 5.—*Number of sampling units required to keep within a standard error of* 15%

Type of herbage	Calculated number of sampling units		
	A	B	C
(a) Important fodder grasses and legumes ..	15	17	24
(b) Less important fodder grasses	19	20	28
(c) Non-fodder species	20	23	23

Now if a difference between the means of two treatments amounting to 10 per cent. is considered enough to show significance the number of replications required can be calculated from the relation—

$$t=\frac{m_1-m_2}{s\sqrt{\frac{2}{n}}} \text{ or } n=2\left(\frac{ts}{m_1-m_2}\right)$$

Where $t=\frac{\text{difference of means}}{\text{standard error}}$. The value of t at 5% level is 1.96, for ∞ degrees of freedom.

m_1=mean yield for one treatment.

m_2=mean yield for the other treatment.

$(m_1=m_2)$ is here taken as 10%.

s=total error (from table 4).

n=required number of replications.

The results are presented below.

Table 6.—*Number of replications.*

Type of herbage	Number of replications		
	1/9th quadrat	4/9th quadrat	whole quadrat
(a) Important fodder grasses and legumes ..	24	25	30
(b) Less important grasses	21	24	29
(c) Non-fodder species	21	22	24

Conclusions

I. *The size of sampling units.*

Of the three sizes tested size A, *i.e.*, 1-9th of .001 acre or 4.84 sq. ft. (say 2.2 ft.×2.2 ft.), is the most efficient with a standard error of 15% of the mean as the limit as will be seen on inspection of tables 4,5 & 6 above although size B, *i.e.*, 4-9th of .001 acre or 19.36 sq. ft. (say 4.4 ft. ×4.4 ft.) is a *close* second for *ocular estimates.*

II. *The number of sampling units.*

The safe minimum number of sampling units, from table 5 above, for the best size of sampling unit, A, was found to be 20, for size B, 23 & for size C, 28.

III. *The number of replications.*

For significant differences of an order of 10 per cent. between treatment means, the number of replications should be 30, as a safe limit, as will be seen from table 6.

Remarks

Complete ocular assessment was done for each of the 100 plots of the *charagah* with the expectation that it would be possible to estimate the loss of efficiency in sampling methods. Below is given a table comparing the mean values based on this total estimation and on various numbers of samples per plot.

Table 7.—*Comparison of mean stocking of important fodder grasses and legumes.*

Source of valuation	Mean stocking.	Difference.	Remarks.
Complete plot estimates	35.3±1.44		
Estimate based on 5 samples	28.4±6.66	6.9±6.81	not significant
Estimate based on 10 samples	26.0±4.84	9.3±5.05	not significant
Estimate based on 15 samples	25.8±4.05	9.5±4.33	significant
Estimate based on 20 samples	25.3±3.61	10.0±3.89	significant
Estimate based on 25 samples	25.3±3.36	10.0±3.49	significant

The complete plot estimates are not significantly different from those based on 5 &10 samples but are significantly different from those based on 15, 20 & 25 samples per plot. This is due to the fact that *ocular estimates* were made for complete plot stocking instead of total weight of herbage. It is therefore not possible, in this case, to estimate the loss of efficiency in sampling, but it must be noted that the greatest care must be exercised when trying ocularly to estimate large areas. *Ocular estimating has severe limits.*

The data of the investigation furnish indications of the size for which ocular estimates an be made validly. There is no significant difference between the estimates furnished by the three sizes of the sampling units, but a useful comparison can be made with the averages furnished by estimates of whole plots in comparison with the sampling means. These are shown in the following statement:—

Table 8.—*Comparison of the reliability of ocular estimates of stocking of herbage (important fodder grasses).*

Size of area unit	Mean stocking	Difference	Remarks
A. Sampling unit—.001 acre	25.3±3.36		
B. 1/9th of .001 acre	31.2±1.43	5.9±3.65	not significant
C. 4/9th of .001 acre	35.8±1.47	10.5±3.67	significant
D. Full plot—.1 acres	35.3±1.44	10.0±3.49	significant

The ocular estimates made in this investigation were thus valid for B, *i.e.*, for plots of .01 acre (or say 21 ft. ×21ft.) but from the data put forward earlier in this note it is possible that ocular estimates should only be made for smaller units than this.

(b) Direct Methods of Pasture Utilisation

On problems of the second kind no results are yet available though some work has been undertaken since the 1939 silviculture conference. The design recommended by Dr. Griffith Davies had 6 replications, with 4 acre paddocks. For sampling he considered 4 random quadrats of 10×5 links per acre as sufficient. In a subsequent letter, however, he pointed out that the six replications in his original note were not the optimum. He considered five replications the absolute minimum.

Actually, whenever possible and practicable, he aims at 9 or 10 replications and all his experience goes to show that ten replicates is the objective to be aimed at. The crux of the problem is that each experimenter has to decide on the number of sampling units, their size and the number of replications for the area he is dealing with for himself, because the variations are so great that a safe rule cannot be framed. A small preliminary investigation, will provide the required data and save a whole lot of trouble later.

GRASSLANDS AND THEIR AFFORESTATION IN CEYLON

By C. H. Holmes

(*Divisional Forest Officer, Silviculture, Ceylon*).

Speaking of grassland one involuntarily* pictures in one's mind the *patanas* of the Uva province. This is but natural for they are indeed in many ways an arrestingly unique feature of the different vegetational types that cover this beautiful island home of ours. But there are several other types of grassland we have also to consider when we take the island as a whole. The grasslands of Ceylon fall naturally into two major upland and lowland groups. Of each of these groups we may distinguish two types so that we have:—

1. The *talawa* of the wet low country.
2. The *damana* of the dry low country.
3. The *dry patana* of the upcountry—principally of the Uva province.
4. The *wet black patana* of the upcountry principally of the Central province.

We have unfortunately no idea of the actual extents of these different types of grasslands and no easy means of making anything like a satisfactory assessment of them. I have sought the assistance of the survey department but even they are apparently in no better position to attempt it. Tenant has estimated the "extent of *patana*" to be "millions of acres" and Federick Lewis in his *Altitudinal Distribution of Ceylon Endemic Flora.*—estimates one million acres of mountain *patana*. A recent article in the *Tropical Agriculturist* puts the extent of the Uva *patanas* to 200,000 acres. This approximates closely with the 192,000 acres or 300 square miles estimated by Pearson in his own classic work, *Botany of the Ceylon Patanas*—From a study of the agricultural map on a scale of 4 miles to an inch, I would roughly estimate the total grasslands of the Uva to be something like 250/300,000 acres. Of this only about half is of dry *patana* type and the balance is *damana*, grassland of the dry zone. It is very difficult, if not impossible, from present maps and data to make even such rough computation of the extents of grasslands in the other provinces but it would be reasonable to suppose that Lewis would not have been exaggerating if in his reckoning he had included the whole of the grasslands instead of merely the mountain *patana* alone.

It is not within the province of the subject of my talk this evening to discuss the origin of these grasslands. There are, as you are aware, several theories as to the origin of the upcountry *patanas*. The general consensus of opinion is that even these arose from the clearing of the original forest and subsequent burning repeated year after year for as long as we can find historical record. There is no dispute that the *talawas* and *damanas* of the wet and dry low-country arose in this way. Nowhere in Ceylon are the climatic conditions inconsistent with the ultimate development of forest. It is a striking fact that there are no differences in fundamental nature between the soils of any of the types of grasslands mentioned and those of the forests immediately adjacent to them. Dr. Joachim's soil researches have established this point beyond all question. Only special site or edaphic conditions and interference by man result in vegetation types other than forest. We must, therefore, regard grasslands as ecological pre-climaxes arrested and maintained in this stage of serial succession by periodic burning and grazing.

Having established their ecological status we should now proceed to a brief consideration of the climatic, edaphic and vegetational characteristics of the different types of grasslands and their distribution before we can deal with the subject of their afforestation.

The *talawas* occur in the low country of the wet south-western quarter of the island. They occupy the lower slopes of the outermost foothills of the central mountain massif and the forested subcoastal hills of the Kalutara, Galle and Matara districts, wedged in between forest of the tropical wet evergreen type and the cultivated lands lower still. The rainfall varies from 100 to 200 inches per annum contributed by both the north-east and south-west monsoons. The soil is generally a very poor truncated lateritic gravel the top soil of which has nearly all been lost completely.

*Lecture delivered recently before the Ceylon Natural History Society.

Needless to say there is hardly a trace of humus. As in the case of the *damanas*, the *talawas* are of the *savanna* type, or, what German botanists (Schimper) called *Savannen Wald*, *i.e.*, grassland dotted by small trees or groups of trees. The grasses,including *Cympogon confertiflorus, Themada tremula, Chrosopogon species, Imperata cylindrica* occasionally, etc., give only scanty cover to the soil. Groups of shrubs *weraniya* (*Hedyotis* species) *bowitiya* (*Osbeckia aspera*) *malkera* (*Ochna squarrosus*) mark the sites of termitaria or pockets of better soil. Patches of low scrub jungle composed of *bedidel* (*Artocarpus nobilis*), *wana-mi* (*Madhuca fulva*), *hedawaka* (*Chaetocarpus* species), *gurukina* (*Calophyllum Calaba*), *welikaha* (*Memecylon* species), etc., occupy shallow depressions or otherwise moister sites. Burning of the grasses by graziers occurs about twice each year on average.

The *damanas* are the most widespread of the different types of grassland we are concerned with. They are distributed throughout the dry zone in areas varying from a fraction of an acre to several hundred acres in extent. The rainfall is generally about 50 to 75 inches per annum and entirely of the north-west monsoon, except for local thunderstorms. There is a prolonged period of drought from February to September and strong dry winds are prevalent from May to July or thereabouts. The soil is generally shallow—sandy, varying from a light sandy loam to a heavy sticky loam—with little or no humus. The grasses are generally of much closer and denser growth than in the *talawas* and more varied in specific composition. Some tracts are entirely *illuk* (*Imperata cylindrica*). Others are of mixed tussock and creeping grasses including *Chrosopogon species*; *Cynodon dactylon*: *Chloris barbata*; *Dactyloctenium aegyptiacum*; *Aristida setacea*; *Digitaria marginata, etc.*, The tree element of this type of *savanna* consist of scattered trees of *mayil* (*Bauhinia racemosa*) ; *ratu wa* (*Cassia marginata*); *diwul* (*Limonia acidissima*); u/ *madan* (*Syzyqium cumini*) ; *dawu* (*Arogeisus latifolia*) in the Uva dry zone, *kahata* (*Careya arborea*), etc. Burning of the grasses occurs on average about once a year.

The remaining upcountry *patanas* are confined to the Uva and Central province. The Dry and wet *patanas* are separated by altitudinal variation and not merely by site conditions. The wet black *patanas* belong to the Central province and occur above an elevation of approximately 5,000 ft. above mean sea level. Rainfall averages about 75 to 125 inches per annum contributed by both monsoons. Solar illumination is low owing to frequent mists and fogs. Strong, mainly moist, winds prevail during the monsoonal periods. The soil is moist often water-logged and very rich in humus which accumulates from a depth of a few inches to several feet. Ground frosts are common in January and February. Soil and air temperatures are low. The grasses are usually more of the tufted varieties—*Chrysopogon* species; *Cymbopogon* species ; *Aristidia setacea*, etc., with different reeds, *Eriocaulaceae* and also mosses. Owing to impeded drainage soil aeration is poor and humic acids accumulate giving low Ph. values. There are few trees associated with this formation except for the *Rhododendron*. Burning takes places periodically about once a year.

The dry *patanas* are mainly of the Uva province where they occur at elevations of about 2,000 to 5,000 ft. The mean annual rainfall is only slightly less than for the wet black *patanas*, say 75 to 100 inches, but except for occasional thunderstorms, comes mainly from the north-east monsoon. There is a prolonged period of draught from February to September as in the dry zone. The solar illumination is intense. Ground and air temperatures are high diurnally and low at nights. There are no frosts. Strong dry winds are prevalent in the months of May to July. The soils are generally truncated sandy to slightly clayey loams mixed with varying amounts of quartz and ferruginous gravel. Drainage is good, though the upper layers of the soil are more acidic than in adjoining forest soils—there is no accumulation of humus nor is there the high acidity of the wet black *patana*. The grasses vary in frequency being very close, heavy and more tufted on the lower slopes and better sites but poor and scanty on the ridges and hill tops. The principal grasses are *Chrosopogon zeylanicus, Cympogonum confertiflorus, Aristida setacea, Themada tremula*, etc. The formation is more purely simple grassland and not generally associated with any tree species except such as may be found on stream banks and in ravines. Burning of the grasses takes place regularly once at least but sometimes twice in the year.

It has been argued more from the point of view of the grazier, I am afraid, than anything else that the periodic burning to which

principally we must ascribe the retention of the grassland state was not wholly harmful but even beneficial. It has been argued in its cause that the burning tended to reduce the incidence of the coarser grasses like the *mana* (*Cymbopogon confertiflorus*) and increases the more palatable and softer grasses. If burning would do this it is not understood why there are yet a preponderance of coarse wiry grasses and so few of the softer palatable ones after all these years of frequent burning! The burning certainly denudes the soil and exposes it to sun and rain. The sun bakes it into hard clods and the rain beats down on them, disintegrates and carries off the soil unchecked by the lack of cover and accelerated by the reduced percolation and increased surface run-off resulting from the consequences of burning. These are facts that cannot be denied and must in proper land management be checked and effectively controlled if so much as happens to be in grassland is not to remain almost unremunerative, and what is worse, condemned to slow but certain degradation and eventual ruin not only of itself but also of regions outside.

To emphasise the importance of taking measures against burning of the *patana* grasslands particularly of the Uva highlands—one need only point to the fact that one important handicap at colonising this salubrious yet so sparsely-populated area now is the scarcity of water. All measures as will reduce run-off must be encouraged and any practices as tend to increase such loss of water must be prevented or controlled. If you will study a topographical map of the Uva province you will also see that much of the drainage basin of certain of the head tributaries of the Mahaweli Ganga is just this dry *patana* grassland. One needs not to wonder how much the well known nature and meaning of the name of this great river is due to the initial clearing of the forests that must once have existed in these parts and subsequent burning of the resultant grasslands.

It is an offence against the existing law and has been so since the Forest Ordinance of 1907 to set fire without authority to any forest. Forest being defined by the same ordinance as "all land at the disposal of the Crown" it is equally an offence to burn any grassland the title to which vests with the Crown. Some years ago there was a movement by certain discerning people to do something to check if not prevent entirely the indiscriminate burning of the *patanas*. It was soon realised that it would be impossible to enforce the law without a very large staff for policing these areas and it was decided to depend therefore on persuasion and propaganda through village councils and revenue officers. No one can claim he has noticed any kind of restriction yet. None is likely to be until the whole matter is more seriously taken than unfortunately it has yet been. On the other hand if such restriction of burning can be made effective it automatically increases, not diminishes, fire hazards. Inflammable material accumulates with protection from burning and if by chance a fire does take place the intensity of the burn and its destructiveness will be greatly increased.

There is one way, however, through which the objects of soil and water conservation urged above could be more satisfactorily served, and that is precisely the main burden of my talk before you this evening, *viz.*, *afforestation*. Paradoxically enough we begin with the removal of the very grasses which we have just been insisting should not be burnt but replacing the grasses by trees we automatically prevent further burning. This immediate advantage will be quite insignificant to several benefits that will ultimately accrue from the change over to forest, *viz.*—

(*a*) Better conservation of soil and water than under the grass cover.

(*b*) Improvement of the soil to a moisture and more fertile condition than possible under the previous state.

(*c*) Increase in economic value of the land and provision of very badly needed fuel and timber for the locality.

(*d*) Provision of shelter to man, beast and food crops from the parching wind, scorching sun and driving rain that is so characteristic of these parts.

The afforestation of grasslands is not merely a matter of planting them with trees. Forest and grassland are two ecological stadia considerably far removed from each other. The forest represents the highest possible development of evolution of vegetational formations dependant on a corresponding build-up of the soil to the degree necessary to sustain forest. The grass stage is one of the earliest in vegetational succession. In a primary succession or prisere it would be nearly impossible or at

least very difficult successfully to establish tree species in grassland. That we are able to do so relatively easily in, for example, the *patanas*, is indication also that the grassland here is not priseral but secondary. The difficulty in case of afforestation of grasslands with tree species amenable to climatic conditions depends on the degree of degradation suffered by the soil from the effects of initial disforestation and subsequent exposure, burning, grazing, erosion etc., in the period of time that has lapsed since. The erodability and degree of degradation of the soil are variable and will not be uniform over any large area. Whilst soil quality may be good and only slightly affected in the plateaux, lower gentle slopes, valleys and pockets of deep soil, the hill crests, ridges and upper slopes generally have lost nearly all of the top soil. In land utilisation schemes the best sites are naturally chosen for agricultural purposes leaving the worst or marginal land for afforestation. This increases our difficulties.

Of the types of grassland we have discussed, we have attempted afforestation experimentally and otherwise in all but one of them, *viz.*, the *damana*. The importance of the afforestation of this type of grassland is less than in the case of the other types if only for the reasons that they are generally or totally flat land and occur in regions still amply provided with forests.

The earliest trials with afforestation of the other types of grasslands—the wet low country *talawa* and upcountry *patanas*—date back to about a score of years. They were for the most part empirical trials to determine suitability of different species. In the *talawas* the Honduras mahogany (*Swietenia macrophylla*); *pehimbiya* (*Filicium decipiens*); *pepaliya* (*Aporosa latifolia*); *ingasaman* (*Enterolobium Saman*); *Mara* (*Albizzia moluccana*); *lunumidella* (*Melia composita*); tamarind (*Tamarindus indica*); *malaboda* (*Myristica laurifolia*), *iriya* (*Horsfieldia Irya*) and a number of other exotic species were tried without success. Trials were made of working the soil to a depth of 3 inches with a view to encouraging better growth without the desired result. Then more determined efforts, were made with pit planting at 9 ft. × 9 ft. espacement in 1½ to 3 feet cube holes filled with forest top soil planted with *jak* (*Artocarpus integrifolia*) and Honduras mahogany. The *jak* failed owing to depredation by hare and not a plant was left at the end of the first year. The *mahogany* survived for some time but, except for a very few that remained here and there in specially favourable spots, also disappeared completely in a few years.

In more carefully carried out experiments selected species were planted out in thrice replicated randomised blocks in the years 1938, '39 and '40. The species tried were—*Alstonia macrophylla*; *godapara* (*Dillenia retusa*); *dan* (*Syzygium caryophyllatum*); *kahata* (*Careya arborea*); *caju* (*Anacardium occidentole*); *guru kina* (*Calophyllum calaba*); *kottaamba* (~~*Anthocephalus cadamba*~~); and *gal-hedawaka* (*Chaetocarpus coriaceus*). The *Dan*, *gal-hedawaka* and *kottamba* failed badly but nearly all the rest gave satisfactory survival percentages until fire which had been prevented for 5 years occurred in 1943 and forced the abandonment of the trials. There was no promise in any of the species used in the trials as regards satisfactory establishment and growth. The *caju* and the *alstonia* were the best but failed to close cover in 5 years though planted only 5 ft. apart.

The principal reason for the failure of these trials is definitely the impoverished soil conditions in the *talawa* type of grassland. Soil deficiency is, if anything, further accentuated by continued sheet erosion caused by the necessity of having to clear and burn the grasses preparatory to planting. With the multiple objects of arresting further erosion, conserving moisture and collecting the little surface soil there is for the plants introduced, we have recently set out a further set of trials with species that have fared best in previous experiments planted in contourwise trenches. Similar measures are known to have proved very successful in India and the first year's results here have already been a definite improvement on anything we had previously obtained.

More comprehensive and concentrated work with regard to afforestation has been carried out in the upcountry *patanas*—particularly of the dry type which are by far the more extensive of the two. The early specific trials included a very large number of species of conifiers and broad-leaved species all of them exotics of temperate or subtropical climes. Amongst the former are the sand and rock cypresses (*Callitris calcarata* and *C. glauca*); *monterey*, Lawson's and the Himalayan cypress (*Cupressus macrocarpa*, *C. Lawsoniana* and *C. torulosa*) Two pines (*Pinus radiata*; *P. patula*); three

Araucarias (*Araucaria Cunninghami*; *Bidwellii* and *Braziliensis*); *Juniperus procera*, *Widdringtonia Whytei*, etc. All the broad-leaved species came from Australia and included principally a large number of *eucalyptus* species (*viz. Eucalyptus robusta, E. rostrata, E. citriodora, E. maculata, E. tereticarnis, E. microcorys, E. saligna, E. regnans* and more recently *E. pilularis, E. diversicolor, E. Maideni, E. gomphocephala* and *E. microtheca*) the latter three species being sent us by an Australian well wisher who happened to pass through Ceylon some few years ago. The other broad-leaved species tried have been *Tristania conferta*, *Syncarpia laurifolia* and *Gravillea robusta*.

Of the conifers only the sand and particularly the rock cypress (*C. Calcarata*) have thrived under *patana* conditions. The *Monterey cypress* has survived and done fairly well in the lower pockets of good soil. None of the others, except perhaps for *Araucaria Cunninghami*, raised under shelter of red gum, have been successful and though some of them have been tried extensively over many years few miserable survivors of a few of them remain. The Australian *Eucalyptus* as a class have given the best results and of them the following have done best—*Eucalyptus robusta, E. citriodora, E. microcroys, E. maculata, E. saligna, E. regnana* and *E. pilularis*. No success has been achieved with the non-Eucalypt species tried and *Gravillea robusta* has proved a signal failure under forest plantation conditions despite its passing success in adjoining tea plantations.

With a fair number of satisfactory and successful species being determined, more recent investigations have concerned themselves with:—the composition of suitable stem and line mixtures of selected species with a view to determining best combinations for general and special site planting; formation treatment details *e.g.*, weeding, patch planting; depth of holing preparatory to planting, thinnings of already established plantations and finally conversion of these exotic plantations to indigenous types by under planting and natural colonisation.

Investigations concerned with the selection and mixtures of suitable species for general planting and special site requirements have confirmed that the Monterey cypress is unreliable and undependable either for wet or dry *patana* planting. The best all-round species has been the red gum (*Eucalyptus robusta*) for general planting in either type of *patana*. The timber *Eucalyptus—E. citriodora* and *E. maculata*—do not stand up to the effects of exposure grown in the wet black Patana grasslands—particularly when grown using the Monterey cypress as a "filler" species. In line or stem mixture with the red gum they are suppressed by the latter. The *E. microcroys* does better but is also suppressed by the red gum in similar mixtures.

All the timber *Eucalyptus—E. citricdora, E. maculata* and *E. microcorys*—do better in the dry *patana* than under conditions obtaining in the wet black *patana*. But in the former too they tend to become suppressed in close mixtures with red gum and do better in plantations comprised of 50 to 75 per cent. of *Callitris calcarata*. The reasons for this besides the differences in growth rates that help keep the crowns of the *Eucalyptus* growing free, are probably also reduced competition for soil nutrients, different feeding root levels and better balanced choice of nutrient substances in short supply. In the poor soils of the tops of ridges, hills and knolls the rock cypress does better than the red gum, outstrips it in height and gives better cover to the soil. Though perhap sa poor best, no more accommodatingspecies than this has yet been found for such sites.

Eucalyptus saligna, E. regnans and *E. pilularis* are remarkably fast growing species that give very pleasing and even spectacular results grown in the lower slopes and valleys with deep moist soils. Generalising from the remarkably better growth of the first species there has been a tendency to regard it as preferable to red gum for general planting. This view has been proved incorrect. It is better used where it does best.

A logical conclusion from the observations made of the behaviour of the different species in the investigations referred to above is that it should be definitely preferable to carry out future afforestation in group mixtures selecting sites to suit the individual species rather than in single stem and line mixtures as done hitherto.

The initial clearing and burning of the *patana* grasses arranging the clods and refuse left in contourwise ridges to reduce erosion is a necessary preliminary to planting. Patch planting removing the grasses in a radius of $1\frac{1}{2}$ ft. around each plant extends the period of establishment from one to five years and

seriously impairs the health and vigour of the plants of all species. Subsequent weeding had up to about 1934 been much overdone following the fetish of keeping the ground bare as used to be the practice in tea estates. From clean weeding regularly on average for a period of 4 years but often to more, large scale trials have established that clean weeding thrice in the first year followed by strip or patch weeding in the second is generally quite sufficient provided the initial clearing and burning has been satisfactorily executed. This condition results in reduction of weeding costs from about Rs. 40 to Rs. 14 per acre or less at pre-war rating.

Another expensive item of work concerned with afforesting is deep holing presumed to be necessary by reason of the existence generally of a compacted layer of quartz and ferruginous gravel at about 18 to 24 inches below the surface of the soil. Several experiments are current with a view to determine to what extent this layer really interferes with the growth of the tree species used. The earlier trials are about 4 years now but no differences are yet apparent between holing depths varying from 6 to 24 inches. It is likely that in the mid and lower slopes a very considerable reduction of holing depth and consequently formation costs could be effected.

Besides other benefits accruing from the afforestation, I claimed it conserved and improved the soil to a moister and more fertile condition than was possible under a perennial state of grass. We have the proof of this in the natural colonisation, by indigenous species of definitely mesophytic type, that is shewing up in our plantations of the dry *patana* grasslands of Errebedde as well as in the Kinigama reserve. These begin to occur about the 10th to 15th year generally but even in about five years in the more favourable situations. In one such area we have under close observation, the overwood now twenty two years old is being gradually removed and we will soon be having a natural forest where less than a a quarter of a century ago was a coarse *patana* grassland. Incidentally another nail in the coffin of the theory that these grasslands are a climax type. An assessment of natural tree-species alone gave a return of approximately 9,000 plants to the acre comprised of the following species:—*beeriya* (*Litsea* species), *kududauwula* (*Neolitsea involuerata*) *bombu* (*Symplocos spicata*); *di-kirilla*. (*Glochidon monatum*); *lunuwarala* (*Schefflera Wallichiana*); *nikadauwula* (*Litsea* species); *kande* (*Macaranga peltata*); *gini sapu* (*Michelia champaca*); *kurundu* (*Cinnamomum zeylanicum* and *multiflorum*) and others—of an average height of more than 10 ft. for the *beeriya* which was the dominant and most frequent species.

We have a total of very nearly 3,000 acres of the upcountry grasslands under plantations and have already changed for the better the whole landscape and environmental conditions particularly in the Erabodde *patanas*. The ministry of agriculture has a big scheme of colonisation which is gradually taking shape and the plantations here, besides serving as much needed shelter belts, are also providing posts, beams, rafters and reepers for the dwellings of the colonists and the firewood wherewith to cook their meals. The war has been responsible for checking progress of work. Our post-war plans provide for a greatly expanded programme of afforestation by which the area afforested here should be doubled in the first ten-year period of the plan. With final victory, we have recently celebrated, we look forward to an early resumption of this most useful service.

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DESERT FRINGE AFFORESTATION*
AREAS WITH A RAINFALL OF BELOW 30 INCHES

BY R. MACLAGAN GORRIE, D. Sc.

(*Director, Soil Conservation Circle, Punjab, Lahore*)

Vast areas of land with a rainfall of 3 to 15 inches in the Punjab-Sind-Rajputana-Baluchistan block of country are showing increasing signs of aridity, and this aridity is also showing definite signs of spreading and extending into lands previously considered safe from desert influences.

During the last 75 years, since first the Punjab was confronted with a fuel famine for railway engines then burning wood, and the foresters established Chhanga Manga irrigated plantation to meet this shortage, the forest department has built up a body of experience in desert fringe reclamation which is parallel with but goes further than orthodox agricultural methods. Tree crops of sorts can be maintained indefinitely on subsoil moisture in many tracts with a high water level, but they must have some sort of irrigation during the first two or three seasons. From afforestation experiments in the arid low hills of Campbellpur district we know of a number of tree species suitable for use in desert fringe shelterbelts. We also know that where no timber trees will persist owing to drought or physiological water shortage, many shrubs and some cane grasses can be used as shelterbelts and wind breaks. We also know that where flood water is available it can be made use of over a much greater area than can be dealt with by orthodox field husbandry by what in America is called "water spreading," the primitive technique of the Navajo Red Indians of New Mexico and Arizona having been greatly improved under the Roosevelt conservation programme. In the Punjab we have applied the Chhanga Manga technique to a variety of sites, soils and irrigation conditions, and having in many places failed to grow timber trees we can confidently undertake to produce efficient shelterbelts.

Whether any of this desert fringe is now producing any farm crops, or worthwhile grazing, or nothing at all, it is all improbable in terms of

(*a*) establishing a better water regime,

(*b*) stopping movement of shifting sand,

(*c*) establishing a more permanent and better livelihood for present occupants,

(*d*) absorbing fresh settlement of demobilised men,

(*e*) exerting a modifying influence on climate, run-off and flood conditions both upon the areas treated and upon neighbouring districts in which increasing aridity is already evident.

The success of any such reclamation depends entirely upon the water regime. We must therefore start by surveying each administrative or geographical unit (say each tahsil of the Punjab) and breaking it up into one or other of the following groups:—

(*i*) Land already under regular irrigation either from perennial or inundation canals, or from wells.

(*ii*) Land regularly subject to flooding along riverain tracts.

(*iii*) Land not at present receiving flood water but which could be incorporated in a water spreading project, by using waste from the tai s of existing canals or by leading flood water further along prepared channels than it normally goes of its own accord.

(*iv*) Land which is not included in any of the above but which has an underground water table level sufficiently near the surface to justify pumping and redistribution by surface channels or afforestation.

(*v*) Land which has no accessib'e water table and which is entirely dependent upon its own scanty rainfall.

All the above groups except No. (*i*) can have their water regime improved enormously by means of water catching and spreading. We must capitalise by catching every available drop of moisture whether emanating from rivers

*Paper read at the 6th Silvicultural Conference, Dehra Dun (1945), on item 6—The Afforestation of Dry Areas

subsoil storage or rainfall, and by getting as much as possible of all these redistributed in order to build up the *field moisture capacity* of every acre of arid land.

Having prepared a rough survey and classification of the land on these lines we have next to undertake a colossal amount of earth working, and this falls under the main heads of (*a*) terracing, (*b*) water spreading, (*c*) working the surface soil to make and keep it more absorptive, (*d*) subsoiling,

Terracing.

This consists of a mound of earth aligned along the contour and planned to run across country in very wide sweeps. The alignment must be particularly accurate on flat ground where advantage must be taken of very small differences of level. Borrow pits or borrow furrows should be on the uphill side of every terrace because silting action will in time fill these pits up with good soil. On land with up to a 3% slope, one good terrace every 200 feet apart measured down the prevailing slope should be ample, the actual cross section of the terrace depending upon the labour and machinery available. With hand labour a steep-sided compact bank with a narrow base is cheapest but with the bullock-drawn *karah* or scoop preliminary ploughing is needed to loosen the soil and a broader-based and lower cross section is desirable. With mechanised equipment the limiting factor is the maximum angle at which the bulldozer or road grader ploughblade can be set away from the horizontal but generally speaking a much broader base, up to say 30 or 40 feet in width, is probably cheapest and easiest.

Spaced at every 200 feet, this gives us roughly 200 lineal feet of terrace for each acre of ground worked over. The typical road grader or bulldozer can complete 3,000 lineal feet of such terracing in a 10-hour working day, so machine power at the rate of one machine day per 15 acres is needed. Failing any supply of machinery the amount of man-power required is no more than has already been used on the older canal projects, but it would require a special organisation to recruit and handle the manual labour which in the absence of machinery would be about 150 man days per acre. In the scattered and often migrant grazier communities of the desert fringe it would hardly be possible to carry out any such project without a large camp for imported labour with all its obligations in the way of food rationing, control of epidemics etc.

Water spreading.

In the arid south western states of Arizona and New Mexico the Federal soil conservation service has perfected various local techniques for the canalisation of torrent runoff or accumulated flood water and its redistribution by means of sills, sluice gates, and distributary channels. The object is to turn the water out into fields or compartments where the water can be absorbed into the soil. It is of course only feasible where the main water channel is relatively flat enough to admit of partial ponding back by a sill, or diversion by means of herring bone deflection spurs built in the main bed while that is still dry. Such diversion is the flat land equivalent of the trapping of hill torrents as attempted in Bihar forest areas by Messrs. Owden and Warren, the object of this being to trap water from the bed of a hill torrent and lead it, as far as possible, round the hillside to encourage seepage. The amount of work and cost involved for flat land water spreading is about the same as for contour trenching, but the pattern is different in that the height and strength of each barrier or conduit decreases with the dispersal of the water, the ultimate field or seepage block being dug with shallow trenches to facilitate flow in the same way as is done in the Punjab irrigated forest plantation technique.

Surface soil working.

Surface soil working is really complementary to both the above heads and is an essential phase in all types of water conservation. In the case of the typical desert fringe the light surface soil, though powdery when dry, quickly develops colloidal characters when wet and the surface after floodwater has spread and partially evaporated becomes puddled and resistant to further seepage. It is therefore essential to have periodic soil mulching done either by hand or preferably with a multiple harrow pulled by a mechanical tractor. To get the best results in terms of percolation through the surface soil it is desirable to have mulching done after every flood or heavy rain when the soil has dried out sufficiently to render soil working easy and effective. The exact time can best be determined for each locality by trial, but the local cultivators will already have their views based on experience. The number of years over which mulching will be needed depends upon the ultimate use to which the improved land is to be put. Long continued water spreading without establishing a crop or tree cover is

likely to produce an excess of sodium clay in the top crust, a condition known as *thur* in the Punjab.

Subsoiling.

A further and much more fundamental operation in soil working is the use of the subsoiler, the value of which is becoming increasingly apparent in many parts of the world cursed with scarcity of water. The subsoil plough consists of an ordinary compact heavy plough shoe fixed at the bottom of a vertical draw bar. It is forced into the ground and drawn through so that the shoe fractures the subsoil at a depth of about $1\frac{1}{2}$ to 2 feet below the surface, but without turning over the sod. This operation renders the subsoil layer capable of storing many more inches of rainfall, but obviously requires a high power tractor. It is hardly conceivable that any ordinary bullock plough team, even in multiple draught, could work it. The value of this tool in dry zone agriculture is already accepted and it is in use in several farms in India. It is claimed that the extra water storage in the subsoil after subsoiling has vastly improved the prospects of dry zone farming both in the yield and choice of crops which can be produced. For our purposes of desert fringe reclamation the subsoiler obviously opens up a new era of hope and activity, because with its use we can get practically the whole of the rainfall into the soil where previously only a fraction of it percolated in and rest went straight off to the sea.

The ideal way to use the subsoiler would be after the main pattern of terrace bunds has been laid out and built, to run the subsoiler through at 8 or 10 feet intervals, keeping its furrows roughly parallel with the main bund. The cost of this will depend to a great extent on the condition and geological composition of the subsoil but an average for desert fringe land with a rubbly but loose layer of *kankar* amongst the sands and clays of alluvial deposits is likely to be about one machine day of 10 hours for every 20 acres with a 10 feet spacing. Tractor operating costs show this to be about Rs. 4 per acre, but only about half of this is fuel, oil and hired labour.

The tractor salesmen's literature indicates that subsoiling deeply is likely to injure rather than help cereal crops where the available moisture is deficient, but this is presumably only a short term effect which will be smoothed out over a series of years, particularly when a better water regime is being established and the chances of building up a better *field moisture capacity* are improving. This factor of deep subsoiling may, however, influence our allocation of land as between farm crops and purely conservation measures. To start with, at any rate, we must keep a high percentage of the reclaimed ground under trees and grass.

Allocation of land uses in reclaimed areas.

Having established the best possible system of water catching it now remains to make the best use of the ground in terms of introducing the most suitable *permanent* dry farming, afforestation, and shelterbelt practice. The choice of crop will naturally depend upon the behaviour of the water in the soil. For cereal straw crops a good field capacity at the 2 to 4 feet level is essential, but gram amongst winter crops and many of the monsoon millets can of course be produced with much less, and cane grass and small trees with less again. Whatever is given out for orindary cultivation should be on a definite understanding of safeguards :— *e.g.*, no browsing animals whatever; ploughing to be along the contour; mulching as per best local practice; maintenance of terrace bunds and sluices; acceptable rotation of crops to be prescribed; maintenance of whatever shelterbelts have been established on neighbouring terrace bunds.

The remainder of the ground must be under shelterbelts with a choice of:—

(*a*) afforestation, and

(*b*) grass production.

In any case grazing must be under very strict control. Afforestation need not necessarily be with timber trees and much of the desert fringe in its present condition simply will not produce them. We can however do a great deal with the giant cane grasses (*Saccharum munja* and *Saccharum spontaneum*) which have previously been treated as weeds in the Punjab. Where the contour terrace bunds are at right angles to the prevailing wind these should be heavily stocked as wind breaks. Where the contour terrace system falls parallel to the prevailing wind then a separate series of wind breaks of grass, trees and bushes must be established, preferably on a system of low bunds at right angles to the wind. The ideal form of shelterbelt to break the force of the desiccating summer west wind is probably an outer and lower fringe of *agaves*, then cane grass and shrubs leading up to high trees in the rear.

The use in Uganda of similar coarse grasses grown as a 3 or 4-year fallow is a recent inno-

vation, the importance of which has not yet been appreciated in India either in silviculture or agriculture. Any coarse cane grass will serve the purpose, as they all produce a very large bulk of cane, leaves and roots from a minimum of moisture. It serves a twofold purpose, firstly by covering the fallow land with a mat of vegetation it reduces surface sheetwash to a minmum, and secondly it provides a mass of vegetable matter which when ploughed under, helps to build up a far better tilth, particularly where sheet erosion has already swept away the top soil and left only a clay or *kankar* subsoil exposed.

Where *Saccharum munja* is at all prolific, as it may readily become under the improved water regime of our proposals, its roots are so big as to present a real problem to the individual cultivator with only his bullocks and a light plough and even after burning the grass tops. The answer is again in mechanised equipment, but the cultivator can only secure its aid either through collective farming, or if government continues to provide the necessary machines and trained staff over a period of years for the proper maintenance of all these conservation items.

The potential value of grass as a means not only of preventing soil erosion but of actively building up a better tilth is summarised clearly in the newly published Imperial Agriculture Bureaux Joint Publication No. 6—*Alternate Husbandry*. From this it would appear that under arid conditions a fairly long *ley* under grass should be followed by a fairly long period under ordinary crops, because the first crop after grass in arid land may be disappointing and the gain is likely to be shown only by subsequent crops which profit by the gradual breaking down in the soil of the grass roots and stems. I suggest that 4 years under cane grass followed by 4 years of other crops should be given widespread trials under all the various combinations of soil and moisture presented by the desert fringe country. We also must learn how far we can eliminate burning which at present is the cultivators' method of exterminating cane grass from any ground he is preparing as a seed bed. The roots are often so massive as to be obstacles even to a heavy mechanised plough, and will in any case take years to rot down unless pulverised before being ploughed under.

No detailed account of desert fringe silviculture can be attempted in this paper, but the following species are likely to form the spearhead of our attack:—

Trees—*Prosopis juliflora*, and *spicigera*.
Acacia senegal, farnesiana, modesta, catechu, leucophloea, arabica.
Tamarix articulata, dioica.
Populus euphratica.
Zizyphus jujuba.
Leucaena glauca.
Maclura aurantiaca.

Shrubs—*Agave* spp.
Sesbania aegyptiaca, aculeata.
Cassia spp.

Grasses—*Saccharum munja, spontaneum.*
Cynodon dactylon.
Eleusine flagillata.
Andropogon laniger.
Pennisetum senchroides.
Panicum antidotale.

NATURAL AND ARTIFICIAL REGENERATION OF TEAK IN BURMA*

BY C.W.D. KERMODE, I.F.S.

(Assistant Silviculturist, F.R.I., Dehra Dun, late Silviculturist, Burma)

The main object of this item appears to be to find out whether the subject is of sufficient importance to warrant a co-operative tour of all teak growing provinces.

The forest department in Burma has had a great deal of experience in the treatment of teak bearing forests and has learnt a good deal about regeneration problems both natural and artificial. Burma has therefore something to teach, but this should not be taken to mean that she has nothing to learn. A co-operative tour should include Burma and Burma representatives should accompany the party to the Indian provinces. At present it cannot be foreseen when it will be possible for a party to visit Burma but there seems no reason to postpone a co-operative tour on that account.

*Paper read at the Sixth Silvicultural Conference, Dehra Dun (1945), on item 5—Natural and Artificial Regeneration of Teak.

Concerning the natural and artificial regeneration of teak volumes could be written and have been. But although so much has been written, especially on artificial regeneration there is still a lot to be learnt. A publication dealing with natural regeneration in a comprehensive way like *Teak Planatation Technique* deals with plantation work would be of value.

A Natural Regeneration

To write up the subject of natural regeneration for Burma would need a great deal of research into old records as it would be desirable to trace the evolution of regeneration methods. This cannot be done here so all that it is proposed to do is to give a few brief notes.

Generally speaking the conclusion has been come to that whereas it is possible to regenerate teak naturally in the mixed deciduous bamboo forests, any system which aims at getting a concentrated crop on the ground is less efficient than regenerating by plantations both on account of uncertainty of success and because such methods have in practice proved to be very expensive.

It would be advisable at the outset to make it quite clear that most, if not all, of the successful examples of natural regeneration were so because the areas chosen already had a good deal of suppressed natural regeneration on the ground. What the regeneration operations did was not so much to induce regeneration but help to establish regeneration that was already there. It may be rather too sweeping a generalization to say that natural regeneration of teak has never been induced by operations designed to do so. It is probable that a certain amount of regeneration has taken place after the various operations and has served to augment what was already there. It is tempting of course to apply the *past hoc propter hoc* argument, but is there anywhere a record with actual figures to show that after a seeding or preparatory felling, there was an immediate considerable increase of teak regeneration on the ground?

Are there any good reasons for assuming that there should be a marked increase in young teak stock as an immediate result of the opening up of the canopy both by felling a certain amount of high cover and removing most of the low cover (bamboo)? The word immediate is important. Under tropical conditions any gap is in the first rains going to be invaded with a dense weed growth.

Statements, such as have been made above, require some backing. This backing can be obtained from a study of the seeding of teak trees and a study of the germination of the seed.

Teak produces seed nearly every year but in comparison with the amount produced by *pyinkado* (*Xylia*) or *ingyin* (*Pentacme suavis*) in a seed year the amount is minute. These two species produce at intervals of a few years large crops of seed of a high germinative capacity. After a seed year the ground even in dense shade can be found carpeted with thousands of seedlings of them. Teak, as mentioned above, only produces a small amount of seed each year and of a much poorer germinative capacity. Germination of seed in nurseries in the open may sometimes be as high as 50%. In the shade of natural forest it varies considerably. In one experiment where the natural forest overhead was mixed deciduous teak bearing, germination was practically nil, on another site with sandy soil in semi-evergreen forest germination reached as high as 15%. On a third site in the shade of *indaing* forest germination was as high or in some cases slightly higher than that obtained in nurseries in the open. These experiments and others referred to under artificial regeneration are mentioned in order to stress the fact that there is still need for research into the germination of teak seed. In fact it is probably an important enough subject to be taken up as a co-operative investigation. An invaluable discovery would be some method of treatment which would enable the seed to germinate freely and establish an advance growth in the shade of good quality teak bearing forest. Such treated seed could then be broadcast just before exploitation operations commenced.

These studies of germination indicate that, in good teak bearing forest with an understorey of bamboo, only a minute fraction of the seed crop dropped each year germinates. It also seems probable that of this crop of seedlings, a high proportion falls to survive to the end of the first rains. This conclusion is admittedly rather speculative and is only based on observation on small nursery beds layed out under shade of natural forest. What little does manage to germinate and survive to the end of the first rains probably can remain alive in

a suppressed condition for many years. This is in contrast again to *pyinkado* and *ingyin*. In their cases an enormous number of seedlings survive to the end of the first rains but after two or three years they have practically disappeared. That young teak can live in a state of suppression for many years has been shown many times. Stump analysis in natural forest demonstrates the fact. The writer has done a lot of stump analysis of teak and can recall one particular case where 40 rings were found in about the first $1\frac{1}{2}$ inch of radius.

It appears that in the better mixed deciduous teak bearing forest there is always a small stock of regeneration on the ground. The amount that appears each year is usually very small but is probably enough and may be locally more than enough to balance casualties amongst suppressed regeneration of earlier years.

In poorer forests such as dry teak or even *indaing* and in places where teak has been planted outside its natural habitat, the amount of regeneration to be found is often very much greater. In the *ingyin* forests of Bhamo teak was at one time regarded as a weed which had to be cut back on account of its interfering with *ingyin* regeneration. (Teak tends to develop as a low branched park like tree in this forest). To generalize again it might be said that regeneration is only normally found in abundance on sites which are only capable of producing the poorest quality.

In the better quality forests therefore it is very unlikely that any opening of the canopy unless it approximates to a clear felling is going to induce much germination. Further, if this germination is induced then weeding must be intense enough during the first two or three years to enable it to survive and get above the weed level.

Burma Forest Bulletin No. 1 gives an example which is worth quoting. It is stated "In Katha division since 1916 it has been found that forest under a nearly pure crop of natural teak can be completely re-stocked with young teak by girdling and allowing a *taungya* crop to be taken under the girdled trees." This treatment is equivalent to clear felling and weeding but there is nothing to show that there was not a heavy advance growth already there. In fact the statement made that "By the end of the first growing season, seedlings have attained much greater height and vigour than is ever attained by dibbling" leads to the inevitable conclusion that the so-called seedlings were not seedlings at all.

There has been a modern development of this method of regeneration which can be used in dry teak forest to regenerate the forest as a whole. It has been found that after exploitation of all marketable timber it is possible to cut and burn all trees and bamboo left, as for a *taungya*, and then either let *taungya* cutters crop for a year or else tend the regeneration departmentally. In one experiment at the end of the first year it was found that 86·1% of squares 6 ft.×6 ft. contained regeneration, 8·1% contained a young teak (this means 97 to the acre). Other valuable and useful species which came up were *pyinkado* (*Xylia*) (56 to the acre) cutch, *Sassia fistula* etc. The growth of teak and cutch particularly greatly exceeded that obtained from seedling plants in a *taungya* and it was obvious that they originated from rootstocks of burnt back advance growth.

From experience gained in the past it is considered that the dry types of teak bearing forest are not suitable for making *taungya* plantations. The ground does not seem able to carry a stock of teak as dense as plantation. Using the above method of natural regeneration a crop can be obtained which normally possesses a fairly high percentage of teak. If the amount of teak is not considered adequate it can be increased by wide spaced stump planting at the time the *taungya* is cut. To determine whether the stock on the ground is sufficient indicator, line counts can be done before *taungya* cutting starts and before leaves have dropped from the undergrowth. Much regeneration of teak can escape the eye in a casual inspection. In dry areas the suppressed teak may only have a foot or so of whippy stem and the leaves drop off early in the season.

To summarise—

(1) In the moist tropical forest where the best quality teak grows any system of natural regeneration which aims at producing a crop of near plantation density is inferior in results to *taungya* plantations and is much more costly.

(2) Natural regeneration is sometimes found in fair amount and operations designed to establish regeneration already present can be successfully

carried out at reasonable cost. The operations consist of improvement fellings. These are now often done at the same time as girdling. A more intensive form of work is carried out in bamboo flowered areas if regeneration appears in abundance.

(3) In the drier teak bearing forests natural regeneration of teak can be established by the use of *taungya*. The same probably applies to moist tropical forest but as such forest is capable of bearing a crop of plantation density it is preferable to regenerate artifically.

B. Artificial Regeneration

All teak plantations in Burma have for many years been made by *taungya*. There is no need to deal with the technique of making them. The two bulletins *Teak Plantation Technique* and *The Problem of the Pure Teak Plantation* deal fully with the subject. A note printed in the 1934 conference proceedings gives full details of the work done in formation and early tending. Only one or two points which have developed since the above were written are worth mentioning. One is seed origin. Three years' tests with teak seed obtained from all over Burma have shown that there is little difference in germination in seed collected in lower and central Burma but that seed from the more northerly teak bearing divisions gave consistently much poorer germination percentages than seed from central and lower Burma.

A second point is the use of stumps. A considerable amount of experimental work has been done and the results are in very close agreement with those obtained in Madras.

Early stump planting gave better growth than that obtained from stump planting at the break of rains or later. By early planting is meant planting from about the 10th—15th of May (the monsoon generally breaks about the 25th). Very early stump planting (Mid-April) where it was successful, gave still better growth. But it was not always successful. In a district like Moulmein with a very heavy rainfall and with probably moisture atmospheric conditions due to the proximity of the sea very early planting could be relied on. In divisions like Insein and North Toungoo where the rainfall is from 80—100 inches very early planting was in the nature of a gamble. In a division like Prome with only 55—60 inches rain and subject to a patchy start of the monsoon very early planting was a complete failure.

Mid-April planting could only be recommended for the most southerly divisions. For all others it was reckoned that if planting started between the 10th—15th May, it would be successful and the resulting plants would be taller at the end of the first rains than they would have been had planting not started until the rains broke.

Although it had been proved that plants from stumps, provided that the stumps were planted not later than a fortnight after the break of the monsoon, produced markedly better height growth in the first year than seedlings stump planting was not generally adopted. The reasons are given below, some are applicable to all stump planting, others only to early and very early planting. They are chiefly financial.

The *taungya* cutter does all the work of cutting, burning, cleaning etc., for nothing and merely gets a reward at the end of the season for the live trees in his *ya*. Sowing seed at stake or planting out tiny transplants involves a certain amount of labour and trouble but stump planting means far more labour. Nurseries have to be made the year before and kept tended. In the year of planting stumps have to be dug up, prepared and planted. In most plantation centres the ground is iron hard until the rains have broken properly. The few mango showers do little or nothing to soften it. It was estimated that for premonsoon planting a man could only prepare and plant 180 stumps a day. With a three acre *ya* he would have to spend twenty days doing nothing but planting stumps. If by getting extra help he did get them all in before the rains broke then he was apt to complain that the extra growth reduced the yield from his crops.

General adoption of stump planting would therefore, considerably increase formation costs as it would be quite unreasonable to expect the *ya*-cutter to take on all this extra work for nothing. Although experiments have not been carried out it seems likely that the extra costs incurred by payment for nurseries and for preparing and planting stumps would not compensate for the saving incurred in weedings caused by the more rapid growth of stump plants.

Wider spacing might help. Planting at $8\frac{1}{2}$ ft. $\times 8\frac{1}{2}$ ft. would reduce the number of stumps to be prepared to half. It would also remove the *ya*-cutter's objections to the young teak spoiling his crops. On the other hand it would mean that, if rewards were kept at the same scale, the cutter would only get half that what he got for 6 ft. $\times$ 6 ft. spacing. The extra cost of stump planting would probably be worth while in plantation centres where *Imperata cylindrica* is abundant. Invasion of a young plantation by this grass causes a great slowing of growth and weeding may have to go on for five or six years which puts up costs a lot. The extra early growth from stump would probably prevent a heavy invasion by *Imperata*.

What the future policy with regard to the making of teak plantations will be it is impossible to say. Since plantation work started there have been several changes in policy. In the early nineteen thirties there was considerable controversy concerning the making of plantations and a number of arguments against planting were put forward. The most important were ; that bee hole borer attack was more severe than in natural forest; that considerable dying off was taking place and that the quality of the timber was not as good as that from natural forest.

Bee hole borer attack can be kept at a minimum both by making plantations in areas of known low incidence and by early and heavy thinnings. Dying off has occurred but only on sites which are now considered unsuitable for making teak plantations, *i.e.*, sites formerly covered by dry teak forest or semi-*indaing*.

The quality of timber has not yet been proved to be inferior to that of natural teak. This argument may have been inspired by trade interests. It is obviously much easier to reap a whole plantation than scattered trees. Hence the forest department would expect to get a higher rate of royalty for plantations while the trade would be interested in getting the plantations at the same royalty as they were paying for the scattered natural teak or for less.

As a result of the controversy government issued instructions limiting the area for annual regeneration by *taungya*. The area fixed was considerably less than that which was being dealt with annually at that time. Teak plantation work was then closed down in a number of divisions.

In 1930, 1,319 acres of pure teak plantations were made. In 1935 the figure had dropped to 927 while in 1939 it was as low as 343. There was a good deal of teak planted in mixture as well as the above and the total areas of plantations in which teak was used either pure or in mixture was 1930—2,550 acres; 1935—1,530 acres, 1939—1,125 acres. This policy was to have been reviewed in 1942.

In the older plantations in Burma some of the best grown trees had reached girths which would have rendered them liable for girdling had they been natural forest trees. It was therefore necessary to decide upon an exploitation policy for these. In a few places plantations were so accessible that everything was saleable and clear felling and replanting was the obvious solution. But this was not the case in most areas and to fell a whole plantation when a few of the trees had reached the 6 ft. 6 in. or 7 ft. 6 in. girth limit was going to involve a great waste of smaller girth trees. It was therefore decided that, with certain excepted areas, old teak plantations should, when they had reached the age of 40 years, have a final heavy thinning when that fell due and should then be transferred to natural forest. They would then receive treatment when the compartment in which they lay was due for girdling or other operations. For example, in a compartment in which teak only was saleable, at the time of the next girdling trees of and above the girth limits in plantations would be girdled as well as the natural teak. At the same time a thinning of trees under the girth limits would be done if needed.* In areas where cultural or exploitation operations took place in the intervals between two successive girdlings it could be prescribed that an ordinary thinning in teak plantations could be done at the same time. In such areas the thinnings would be saleable. In the inaccessible areas thinnings would not normally be saleable but when done in conjunction with girdling the better trees from thinnings would be extracted by the lessees.

Artificial regeneration with teak is not entirely a matter of making plantations whether

*The girdling orders made provision for thinning in congested clumps of natural teak which were below the exploitable girth.

pure or mixed. Other methods of introducing teak artificially have been tried. For convenience they may be classified as

(1) gap planting,
(2) planting or sowing in areas where bamboo has flowered or is expected to flower,
(3) "supplementing" in natural regeneration.

(1) Gap planting

The difference between a gap and a plantation is one of degree only. Reduce a plantation area to a size where only one tree can be planted and the simplest form of gap is reached. Increase the gap to a sufficiently large area to make it worthwhile for a *taungya* cutter to come and work it and the gap has become a plantation.

Some experiments in gap planting were carried out just before the war. These were done in the Kangyi reserve, Zigon division which contains very fine mixed deciduous forest without bamboo containing a high proportion of teak, *pyinkado* (*Xylia dolabriformis*) and *taukkyan* (*Terminalia tomentosa*). This forest has been worked on a natural system and has been kept fire-protected for many years. The system has resulted in magnificent regeneration of *Xylia* but teak regeneartion has been poor. Several attempts to correct this were tried. One was to plant stumps of teak under girdled teak or marked *pyinkado* in the hope that, as soon as the trees were felled, the stump plants would be able to shoot ahead at once and keep pace with or outdistance weeds. This proved almost a complet failure. Gap planting was next tried. Immediately after felling, gaps, caused by the felling of one or two large trees, were selected. Where there were trees of valueless species nearby these were felled to enlarge the gap. A series of gaps varying from ·37 to ·7 acre was obtained. Undergrowth was cut and all debris burnt. Gaps were planted up with one year old stumps 6 ft. × 6 ft. in May. In a few of the gaps villagers were allowed to plant paddy etc., so that they become miniature *taungyas*. Results at the end of the first year were only moderate; percentage survival varied from 26 to 67 and average heights from 15·5 inches to 33·3 inches. The most important factor seemed to be drainage, the area was nearly flat and water was apt to lie on the ground for some time. Light seemed to be of secondary importance. Trees were not so robust as those grown in an open *taungya*. As far as the work went it showed that it was possible to stock gaps in this way but the tentative conclusion arrived at was that it was not worth while unless gaps were available of, or could be enlarged to, 4—5 acres. Having got gaps of that size it would be far more economical to regenerate them by small *taungya* plantations.

(2) Bamboo flowered areas

The flowering of *kyathaung* (*Bambusa polmorpha*), which is characteristic of the best quality teak forests, had been expected for a good many years and it was anticipated that when it did start it would flower gregariously over hundreds of square miles in the Pegu Yomas. It was hoped that advantage could be taken of this flowering to increase artificially the teak stock.

Gregarious flowering started about 1935 but did not proceed so rapidly or cover such large areas as was anticipated. The original aim of artificial methods was to cover as large an area during the actual year of flowering as possible. The first rains after flowering would find the area more open than at any other time. After the first rains it was thought that weed growth and regrowth of bamboo would be too dense to enable operations to be done cheaply. As areas were expected to be very large it was not considered that any tending operations would be possible unless there were indications that a good deal of regeneration was starting to push through. Broadcasting and dibbling of seed and stump planting were chosen as the methods to employ. Broadcasting and dibbling were naturally first choice as there were only stumps available, in the first year that flowering started, for some small experimental areas. Large areas were broadcast over and a number of small plots for check were also done. These latter were counted out later. Broadcasting turned out to be practically a complete failure. Dibbling was only done over some small plots and was also a failure. Stump planting was a modified success, in that a certain number of plants were able to survive even under dense weed growth. It was obvious though that it was not worthwhile stump planting large areas and leaving them to look after themselves. Areas treated would have to be much smaller and would have to be tended for a year or two.

Later, stump planting on a moderate scale was carried out and tending was done. This was successful but too expensive and it was found that in bamboo flowered areas where the stock of valuable species was very low a modified form of *taungya* was very successful. In this villagers wanting land were encouraged to come into reserves and cultivate these poorly stocked areas provided that they planted teak stumps. Stumps were provided by the forest department. These stumps were not put in at normal plantation spacing but were planted in groups of four, 6 ft. × 6 ft. in the group. The outside of each group was 20 ft. away from the outsides of adjoining groups. Growth proved to be very rapid and weeding for one year only after cultivation was completed was on the best sides sufficient to get the teak above the level of the sea of *Eupatorium* which invaded the areas.

When flowering was going on it was thought that it might be possible to anticipate it in as yet unflowered areas and get plants established as advance growth before the flowering so that, as soon as this took place and opened the cover, the advance growth could go ahead. Some experimental work done on this by planting stumps under unflowered bamboo showed that the survival percentage at the end of the first rains was far too low to render the method of any practical importance.

(3) "Supplementing" in natural regeneration.

This method is only in the experimental stage but appears to hold great promise under certain conditions. It has been found that in certain forests it is possible, after completion of extraction, to cut and burn all remaining growth and cultivate a *taungya* for a year without doing any planting. There is so much regeneration which either survives the fire or comes up from seed in the ground that crops of a density approaching that of a 6 ft. × 6 ft. plantation can be obtained. Some of the types of forest dealt with have been evergreen, semi-evergreen dry teak forest and degraded types. If *taungya* is done as mentioned above the resulting crop is a mixture of a lot of species some useless and some useful. Indications are that by planting teak stumps widely in this natural matrix the year the *ya* is cultivated a very valuable addition to the natural crop can be obtained on suitable sites. In fact it seems possible that, in specially favourable areas, it may be possible by starting with a spacing of something like 20 ft. × 20 ft. to finish up in the end with what is virtually a pure crop of teak. Seedlings are not likely to be so successful as stumps, as rapid initial growth is needed to enable the plants to keep pace with the rapid growing shoots of the natural species on the area. Experience so far gained with this system in dry teak forest indicates that there is usually enough teak which comes through naturally.

STUMP PLANTING OF PROSOPIS JULIFLORA

BY S. N. DABRAL

(*Silviculture Ranger, Forest Research Institute, Dehra Dun*)

The artificial regeneration of *Prosopis juliflora* has been attracting a great deal of attention recently but experimental evidence comparing the different methods of its artificial regeneration are meagre. This particularly applies to stump planting.

Griffith (1940 & 1941) shows that in the Madras dry fuel forests direct sowing is the best method of regenerating this species and that stump planting leads to almost complete failure. Mohan (1940) states that stump planting can be successfully done but does not compare sowing, transplanting and stump planting. Bhargava (1945) describes a method of planting stumps, that have previously been planted in grass baskets though the comparative success of the various methods is not mentioned.

From germination and other tests with *Prosopis juliflora* and *P. glandulosa* (reported in the *Indian Forester* for January and August 1945) stock was obtained and this was utilised to compare stump planting and transplanting in the climate of Dehra Dun.

Stock used

The plants from the germination tests of *Prosopis juliflora* (Australian variety) were growing under laboratory conditions in the glass house and of *Prosopis glandulosa* under field conditions in a nursery bed. The plants

were 10 months old when dug up and planted out.

100 seedlings of *Prosopis juliflora* were selected comparable as regards height, root length and stump diameter at the collar which varied from 0·5 inches to 0·6 inches. 50 were made into stumps with 1 inch of shoot and 9 inches of root and the other 50 were planted as entire transplants.

The seedlings of *Prosopis glandulosa* were 12 months old and too big to be dealt with as transplants as the average plant was over 1½ feet high. All 300 were therefore planted as stumps.

Method of planting and tending

In making the stumps it was noticeable that the *Prosopis juliflora* seedlings had very fibrous roots while those of *Prosopis glandulosa* had straight, clean roots. Planting was done in the last week of July under very favourable conditions in crow bar holes in well drained but rather hard soil in which the response of stumps of *Dalbergia sissoo* and *Morus alba* was encouraging. As this was only a sighting test to see whether further tests were advisable, a layout AB, AB, AB, etc. was adopted for the transplants and stumps respectively. The *Prosopis glandulosa* stumps were 0·5 inches to 0·8 inches in diameter. Normal plantation weeding and tending was done.

Results

At the end of the rains (in early October) the survivals were enumerated and measured for height with the following results:

	Survival percentage		Mean height increment in inches	
	Transplants	Stumps	Transplants	Stumps
P. juliflora	78	4	4·3	3·5

The above was from the two sets of 50 plants mentioned above. In another set of 290 transplants of *Prosopis juliflora* 79% survived.

With *Prosopis glandulosa* out of 300 stumps tried, only 5% produced shoots but all subsequently died.

It is realised that the climate of Dehra Dun is unlikely to be suitable for these species and the survivals are being kept under observation to see whether they survive the cold winter.

The above results are interesting confirmation of the Madras experience that *Prosopis* stumps do not do well particularly as the Dehra Dun rainfall averages 85 inches per year as compared with the 25 to 30 inches of the Madras dry fuel forests.

NOTE

We would particularly welcome comparative data of the results of sowing, transplanting and stump planting *Prosopis* species in different climates as large scale work with these species is envisaged in several provinces in the next few years—*Central Silviculturist.*

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EXTRACTS

A TREE-RING CALENDAR IS MADE FOR MESA VERDE

The first people to live on the Mesa Verd were a group of Indians, now called the Basket Makers. They lived in the region from about the time of Christ until the year 700. They were a long-headed people with short slender bodies. They lived in the open caves, where later the great cliff houses were built.

The Basket Makers were farmers, raising corn and squash on the top of the mesa. They made good baskets which were used for many different household purposes. Several hundred years later they learned to make a plain gray pottery.

About the year 700, the later Basket Makers gradually began to disappear. Another group of Indians came into the Mesa Verde region. They were a short, heavy-set, round-headed people known as the Pueblo Indians.

The story of how the Mesa Verde cliff dwellings were dated so exactly is really the story of a great piece of scientific detective work.

Dr. A. E. Douglass of the University of Arizona had been studying sunspots before he became interested in making a tree-ring calendar. He knew that changes in the sun affected the weather and that changes in the weather affected the growth of trees. He also knew that for every year of its growth a tree adds a new layer of wood. By counting these layers of wood, or growth rings, it is possible to tell the age of a tree.

What is even more wonderful, the growth rings tell the story of a tree's life. This is especially true in the dry regions of the southwest, where the most important thing to both man and trees is rainfall. In dry years the growth rings are small, and in wet years they are large. This record of lean years and fat years, of drought and plenty, appears in the trees of an entire region just as surely as if a diary had been kept. In fact, the growth rings are a diary of the life of any tree.

This fact made it possible for Dr. Douglass to build a tree-ring calendar which is now used in fixing dates for the ancient ruins of the southwest. First he cut down the oldest living pine tree he could find and counted the rings. If, for example, a tree cut in 1925 had 225 growth rings, it was 225 years old and had started growing in the year 1700.

But this record of living trees did not go far enough back. So Dr. Douglass visited some of the old Indian villages in Arizona which had been occupied for at least four or five hundred years. Here he took samples from the logs which had been used in building both the newer and the older houses. These samples were then arranged so that the older inside rings of a living tree were matched exactly with the outer rings of a tree which had been cut several hundred years ago.

Next he went to the ruined pueblos and cliff dwellings which were still older. Here also he took samples from the logs which had been used in these ancient buildings. Again the sample were matched until the telltale rings showed the same record of drought and plenty. In this way he was able to make an unbroken tree-ring calendar going back to the year 700.

Many of the tree samples used by Dr. Douglass were taken from the ruins in Mesa Verde National Park. By matching those samples with the tree-ring calendar it is possible to tell the year in which the tree was cut. Since the log was probably used in the building soon after it was cut, the year in which the part of the cliff village was built can also be determined. And so by making the tree rings talk, the priceless secrets of America's ancient past are no longer the mystery they once were.—From *Our Country's National Parks.* by Irving R. Melbo. (Indianapolis Bobbs-Merrill, 1941).

—*Christian Science Monitor*, 16*th June*, 1945.

WATERSHED FLOOD CONTROL: PERFORMANCE AND POSSIBILITIES

BERNARD FRANK AND E. N. MUNNS

(*Assistant to chief, Division of Forest Economics and chief, Division of Forest Influences, respectively, U. S. Forest Service, Washington, D. C.*)

Foresters and other conservationists have been acquainted only to a limited extent with the watershed phase of the national flood control program. The results of five years' activity in this field now permit a thorough appraisal of performance and possibilities. Detailed analyses of the program and especially the completed survey reports reveal desirable and undesirable features involving both principles and procedures. Because of the sharp significance of flood and sedimentation damage and the increasing responsibility of land users and managers in its alleviation, results of the watershed investigations and operations here described are of considerable practical interest.

The Omnibus Flood Control Act of June 22, 1936, established new policies. It reorgnized new principles. It created new programs. Most important from the standpoint of foresters, it recognized that the control of floods begins on the watershed. It is here that flood troubles start and erosion takes place. It is here the cure must begin.

This 1936 Act had its genesis in the severe spring floods of that year. These climaxed a decade of nation-wide valley overflows of alarmingly frequent occurrence and increasing heights. Direct flood damages, already high, that spring increased to some $35,000,000 annually, to which could be added indirect damages variably estimated at from one-half to twice the direct losses (6). Although the Congress had previously recognized the flood problem in the Missisippi Delta region, it had given comparatively little attention to the situation elsewhere. Deeply concerned now with the nation-wide extent of the losses and their magnitude, the Congress authorized a comprehensive national attack on the problem. In this it called upon both the engineers of the War Department and the technicians of the Department of Agriculture.

Department of Agriculture activities under this legislation began in 1937. They continued until June 30, 1943, when such work virtually ceased because of war conditions. During this period several million dollars were spent, mostly on the detailed studies of individual watersheds. As the programme is not well known and as many foresters have expressed interest in it and concern over its progress, it seems appropriate to take stock of the situation and to analyze results. Because the survey program is the all-important planning step, most of the attention here will be specifically directed to it.

BASIC PROVISIONS OF FLOOD CONTROL ACT

Section 1 of the Flood Control Act establishes constitutionality and policy. "It is hereby recognized that destructive floods upon the rivers of the United States, upsetting orderly processes and causing loss of life and property including the erosion of lands, and impairing

and obstructing navigation, highways, railroads and other channels of commerce between the States, constitute a menace to national welfare: that it is the sense of Congress that flood control on navigable waters or their tributaries is a proper activity of the Federal government in co-operation with States, their political sub-divisions, and localities thereof; that investigations and improvements of rivers and other water-ways, including watersheds thereof, for flood control purposes are in the interest of public welfare; that the Federal government should improve or participate in the improvement of navigable waters or their tributaries, including watersheds thereof, for flood control purposes, if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected."

Section 2 reads in part "that, hereafter, Federal investigations and improvements of rivers ......for flood control and allied purposes shall be under......the War Department....,and Federal investigations of watersheds and measures for run-off and waterflow retardation and soil erosion prevention on watersheds shall be under the jurisdiction of and shall be prosecuted by the Department of Agriculture under the direction of the Secretary of Agriculture...."

Section 6 states, "The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys for flood control at the following named localities, and the Secretary of Agriculture is authorized and directed to cause preliminary examinations and surveys for run-off and waterflow retardation and soil erosion prevention on the watersheds of such localities......." Then follows a long list of "localities," which in most instances are names of streams. The watersheds of the "localities" specified in this and subsequent legislation embrace about 90 per cent. of the nation's area.

Legislative Amendments and Interpretations.

Supplementary acts have clarified this first legislation, authorized appropriations for construction activities, and extended the powers of both departments. Of special interest is Section 7 of the Act of June 28, 1938, which in part provides, "That in order to effectuate the policy....and to correlate the program for the improvement of rivers and other waterways by the Department of War, with the program for the improvement of watersheds by the Department of Agriculture, works of improvement for measures of run-off and waterflow retardation and soil erosion prevention on the watersheds of waterways, for which works of improvement for the benefit of navigation and the control of destructive floodwaters and other provisions have been adopted and authorized to be prosecuted under the direction of the Secretary of War......are hereby authorized to be prosecuted by the Department of Agriculture under the direction of the Secretary of Agriculture and in accordance with plans approved by him."

These basic acts and legislative grants of authority provide simple, broad, and general directives. They give the Department of Agriculture wide latitude. They place but few restrictions on its program and these are relatively minor.

In 1941 the Supreme Court in the so-called Denison Dam case (*U. S. v. Oklahoma, 313 U. S. 508*), interpreted the policy statement, outlined the scope of damages suffered and benefits to be obtained, and indicated some of the elements which should enter into the evaluation process. As this decision is not generally available, excerpts are quoted:

"The contribution which the Red River makes to disastrous floods....has long been recognized. Huge crop damage, the loss of buildings, bridges and livestock, pollution of fertile fields, the erosion of rich farm lands, bank cavings, interruption of navigation, injury of port facilities, the creation of sand bars in the channels, interruption or stoppage of interstate transportation by rail, truck and motorcar, disease pestilence and death, relief of the homeless and destitute—all these are now familiar costs of the floods on the Mississippi. And the history of the Red River valley shows that it too has long been plagued by such disasters and burdened by their costs.

"A part of the local benefits of flood control is frequently protection of navigation in the tributary itself. That is present here to a degree

......(although) no part of the Red River within Oklahoma is navigable......And it is clear that Congress may exercise its control over the non-navigable stretches of a river in order to preserve or promote commerce on the navigable portions........Congress was not unmindful of the effect of this project on the navigable capacity of the river...... The Acts in question contain a declaration that one of their purposes is to improve navigation.... And the.....Denison Reservoir will have at least an incidental effect in protecting or improving the navigabilty of portions of the Red River.

"We would, however, be less than frank if we failed to recognize this project as part of a comprehensive flood control program for the Mississippi itself......There is no........ reason why Congress cannot, under the commerce power, treat the watersheds as a key to flood control ......Nor is there a constitutional necessity for viewing each project in isolation from a comprehensive plan covering the entire basin of a particular river......We need no survey to know that the tributaries are generous contributors to the floods of the Mississippi. And it is common knowledge that Mississippi floods have paralyzed commerce in the affected areas and have impaired navigation itself. We have recently recognized that 'Flood protection, watershed development, recovery of the cost of improvements through utilization of power are likewise parts of commerce control.' *United States v. Appalachian Power Co.* And we now add........flood control extends to the tributaries......For just as control over the non-navigable parts of the river may be essential or desirable in the interests of the navigable portions, so may the key to flood control on a navigable stream be found in whole or in part in flood control on its tributaries.

"......the extent to which this project will alleviate flood conditions in the lower Mississippi is somewhat conjectural......The control provided by the Denison Reservoir on the Red River summer floods has been estimated to produce a reduction of approximately 0.6 feet.... The reduction while not substantial....is important...... A War Department survey reveals......prospects in a system of 157 reservoirs throughout the tributaries of the Mississippi. To say that no one of these projects could be constitutionally authorized because its separate effect on floods in the Mississippi would be too conjectural would be to deny the actual or potential aggregate benefits of the integrated system as a whole."

PRELIMINARY EXAMINATIONS

Flood control legislation provides for three classes of activities: preliminary examinations detailed surveys, and the prosecution of watershed operations.

The preliminary examination (PE) provides the first approximation of the technical and economic feasibility of undertaking an operations program in a given watershed. Data on floods and damages are compiled and general information on watershed conditions is assembled. Only enough factual material is collected by the small group engaged to obtain a picture of over-all conditions in the drainage basin and the relation of land use and abuse to flood troubles. The report on " preliminary examinations shall include: (1) a determination as to whether flood damages are such as to warrant a flood control survey;(2) a judgment ......as to whether a program appears to be justified; (3) a judgment as to the flood and silt source areas and the type of program required; and (4) a statement describing the general overall land use plants for the watershed." (9).

Survey priorities are established in part on the basis of the PE findings. Also determined is that portion of the drainage basin in which survey activities should be concentrated. Should the PE reveal little or no opportunity for an upstream program, that fact is made known to the Congress, and thereafter no further work is possible in the area unless Congress so authorizes. The PE reports are usually brief and are not commonly published.

The first funds became available in 1937, since when PE reports have been prepared on some 160 watersheds. Of these, 123 recommend more detailed study within the drainage basin examined. In the light of subsequent experience some early reports omitted essential facts and others went into far more detail than was required. All in all, however, they assembled much significant information on watershed conditions and problems, and have proven valuable to the participating agencies.

Detailed Surveys

The second step is the "detailed survey." As its major purpose is to develop specific plans for watershed rehabilitation, it is probably the most critical phase of the flood control program. Here the best technical knowledge, deepest thought, greatest imagination, and maximum skills must be used to determine the combination of land, use measures and practices that] will provide the maximum reduction of damages. If a complete program land treatment for the entire watershed proves uneconomical, separate studies of smaller unit or homogeneous areas are required to develop a feasible program for at least part of the area in need of treatment. The degree to which the survey party employs imagination, ingenuity and aggressiveness determines in very large measure whether any kind of a remedial program can be recommended.

The evaluation of the remedical program is not a simple task. It requires careful study of many factors, among which some of the more important are the causes leading to floods and erosion; flood and sedimentation damages in relation to the character, use, and condition of the upland areas; measures that might abate damages and their cost; hydrologic effects of changes in land use and practices; and an evaluation of the program in terms of benefits produced. Because most land is in private ownership and upstream owners seldom participate in benefits accruing downstream, full consideration must be given to their economic interests so their participation in a program may be readily obtained.

The field party on a typical survey includes soil conservationists, agronomists, foresters, geologists, hydrologists, agricultural engineers, economists, damage appraisers, and farm management specialists. In a well-operated survey each activity leads by consecutive steps toward a central objective. The damage appraisals relate to the flood flow and sediment measurements of the hydrologists and geologists, and in turn to the findings of foresters, agronomists, and others concerning upland soil and cover conditions. Measurements of soil and water losses are related to soil and cover types as influenced by climate and use, and in turn to the magnitude of downstream discharges. Analysis of past floods and rainfall records indicates the probable frequency of future floods of given volumes or stages and their effects upon damageable values in the flood plain. Investigations of the physical, economic, and institutional factors influencing land use and ownership are harmonized with findings on damages and their causes to develop programs for the several homogeneous sub-divisions of the drainage. And finally the costs of installing and maintaining the program are compared with the various flood plain and upland benefits estimated to result. Recommendations are then made for or against operations depending upon the ratios of monetary benefits to cost for each portion of the watershed considered as a separate entity.

Appropriations in 1938 permitted an expansion of the PE program and the initation of detailed surveys. In the lack of adequate PE's to guide the selection of areas, and in the belief that an economic program could be developed without difficulty, an administrative decision was reached to begin a number of surveys. Upon advice of members of the Corps of Engineers,* the first surveys were started on southern California, St. Francis, and Youghiogheny River drainages. It was their expressed belief that upstream programs in these basins could aid materially in alleviating local flood problems and supplement the downstream programs for these areas. In the southern California basins, the flashy character of the flood flows and the enormous quantities of debris coming from the mountain lands were causing them concern. In the St. Francis River watershed, the Wappapello Dam was being constructed and it was thought the land program would be helpful to reservoir operation. The Youghiogheny River watershed was suggested because it was a large contributor to flood damages at Pittsburgh and the Corps of Engineers had not yet formulated a program.

Later and without further advice from the engineers, other areas were approved for survey. By the end of 1938, 17 surveys were under way. They extended from New England to California and from Wisconsin to Texas, involving altogether parts of 21 states. The watershed represented sampled all major types of climate soil, cover, and land use.

Fifty-one surveys embracing some 300,000 square miles were authorized by the Secretary

*Major Max Tyler and Capt. L. D. Clay, then in the Office of the Chief of Engineers. Maj.-Gen. Tyler is now president of the Mississippi River Commission and Maj.-Gen. Clay is director of Material. Army Serivce Forces.

of Agriculture during 1938-42.* Under flood control legislation, final reports on all surveys after approval by the Secretary go to the Congress. As of May, 1944, 17 reports had reached Congress. Of these 9 recommended action programs under flood control legislation for all or part of the drainage basin concerned. The latter reports are published as House documents.

WATERSHED OPERATIONS

The operations phase is the final step in the flood control program. Here action is taken to carry out survey recommendations: land management measures are put into effect, and improvements installed.

The nature of the program naturally will vary with the needs of the individual watershed. In general, the farm land program includes such measures as better practices, changes in types of crops grown, greater use of lime and fertilizer, strip cropping, the use of terraces, etc. Pastures are furrowed, reseeded, and otherwise improved. Farm woods are protected from grazing and fire and waste lands are reforested. Where necessary, minor engineering devices such as basin listing or check dams to hold soil or water are employed.

On forest lands, the strengthening of the existing cover is the primary need. This involves the prevention of overcutting and more adequate fire control. The rehabiliation of raw soils requires reforestation of denuded lands reseeding of depleted ranges, and revegetation of road banks. Under some circumstances where cover cannot quickly reclaim the soil, these measures are supplemented by contour trenches and related devices. Where the bed-loads of minor streams are heavy, debris basins or channel stabilization devices may be utilized to supplement the cover.

However important, the installation of any measure is only the first step towards proper management of the soil and its cover. Even though a great dam can provide flood control, it is only in its operation that real protection is achieved. So in the upstream program: only as measures are kept up can we expect full flood control benefits. Terraces soon lose their value if not maintained; reseeded and fertilized passtures do little good if they are cotinuously over-grazed. Reforestation is of no moment if the plantations are regularly overgrazed or burned.

Operations will be undertaken on public lands by the responsible administering agencies and on private lands via legally constituted owner-operator associations acceptable to the Secretary of Agriculture. Soil conservation districts fall in this class. On forest lands, operations will be under the general direction of the Forest

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*The secretary has approved and the Congress has published survey reports for the watersheds of the following nine streams; Los Angeles River, Calif. (H. D. 426, 77th C. 1st s.); Upper Trinity—River, Tex. (H. D. 708, 77th C. 2d. s.); Little Tallahatchie River, Miss. (H. D. 892, 77th C. 2d. s.); Coosa River, Ga., (H. D. 236, 78th C. 1st s.) ; Little Mioux River, Ia. (H. D. 268, 78th C. 1st s.); Potomac River, Va. (H. D. 269, 78th C. 1st s.); Washita River, Okla. (H. D. 275, 78th C. 1st s.); Middle Colorado, Tex. (H. D. 270, 78th C. 1st s.) ; and Santa Ynez River, Calif. (H.D. 518, 78th C. 2d. s.).

The Secretary has approved the following reports favorable to an upstream program but they have not as yet (May 1, 1944) reached Congress: Kickapoo River, Wis.; Buffalo Greek, N. Y. and Yazco River, Miss. The Secretary has also approved a number of survey reports recommending agaist an upstream program: St. Francis, Mo ; Muskingum, Ohio ; Upper Musequehanna, N. Y.; Wolf Greek, Okla.; Billings, Mont. ; Pajaro, Calif; and Codorus Greek, Pa. "Negative" reports are not printed by Congress unless especially authorized.

Watersheds authorized for survey by the Secretary of Agriculture but on which no final reports have yet been made include:

San Gabriel River, Calif.	Allegheny River, Pa.*
Santa Maria River, Calif.	Crooked Greek, Pa.*
Santa Ana River, Calif.	Youghiogheny River, Pa.
Queens Greek, Arizona	Roanoke River, Va.*
Upper Gila River, Ariz.	New River, W. Va. and Va.*
Fountain Greek, Colo.	
Cherry Greek, Colo.	PeeDee River, N. C.
Walla Walla, Wash.	Kaskaskia River, Ill.*
Boise River, Idaho	Whitewater River, Minn.
Sevier Lake, Utah	White River, Mo. and Ark.
Pecos River, N. Mex.	
Grand (Neosho) River, Kans. and Okla.	Lower Arkansas River, Ark.
Salt Fork, Okla.	Ouachita River, Ark.*
Raccoon G reek, Ohio	Rio Puerco River, N. Mex.
Connecticut River, Vt. and N. H.	Upper Rio Grande River, N. Mex.*
Merrimack River, N. H. and Mass.	Willamette River, Ore.*
Kiskiminitas River, Pa.*	Concho River, Tex.

Starred drainages, are those on which little or no survey work has been done.

Service but using existing co-operative machinery wherever possible. This procedure puts part of the responsibility for the success of the forest land program on most if not all public forestry agencies in a watershed.

Operations are under way within the Los Angeles River watershed, the first for which an upstream survey was completed. Before any work was undertaken, a memorandum of understanding was reached with each public body that would have a part in the program and signed by representatives of the state the counties, and the cities affected. The work on farms and ranches is being carried on through the instrumentality of the Los Angeles County Flood Control District, specific co-operative agreements and technical services being handled by the Soil Conservation Service. The mountain work, mainly within the Angeles National Forest, is being performed by the Forest Service in co-operation with the state and local public agencies. Although the program for the entire Los Angeles River basin was approved, initial funds were limited to two segments, the San Fernando Valley and the Arroyo Seco. War preparations and the present conflict temporarily stopped the operations program in both areas and caused postponement of work on other watersheds for which remedial programs were approved.

The denudation by fire of portions of important mountain watersheds elsewhere in southern California created the threat of heavy debris flows to valley communities and highly developed agricultural lands. This emergency situation on three occasions was met by the release of flood control funds for quickly applying remedial measures of a type recommended for the Los Angeles basin. These included the reseeding of burns, channel improvement, and road-bank stabilization. In the subsequent flood seasons, this work demonstrated its effectiveness in reducing and retarding surface runoff, in preventing erosion at the source, and in checking debris movement in the channels.

The Flood Control Organization

The original flood control organization of the Department of Agriculture consisted of a Washington Flood Control Co-ordinating Committee representing the Bureau of Agricultural Economics, the Forest Service, and the Soil Conservation Service, with a chairman from the Secretary's Office of Land Use Co-ordination. Field co-ordinating committees, similarly constituted as to bureau representatives, were established throughout the several "committee regions" of the country. The chairman in each region was selected from the action agency assigned major responsibility for programs there. Survey parties, their leaders chosen from the respective chairman agencies operated under the direction of field sub-committees. Party members were furnished from the three participating bureaus, and reported directly to the parent agency.

In October, 1938, a re-organization of the whole Department of Agriculture was effected in which the function of general land use planning was assigned to the Bureau of Agricultural Economics. As the flood control program appeared to constitute such planning, responsibility for all activities under it except operations was assigned to the chief of that bureau. Committees were retained, but chairmanships both in Washington and in the regions were assigned to members of the B.A.E. Leadership of survey parties remained in the action agencies. Party makeup remained the same.

As the watershed surveys represented a stage of planning far more detailed than general area planning was conceived to be, another re-organization followed. In February, 1941, an "Officer-in-Charge of Flood Control" was established in the Office of Land Use Co-ordination with responsibility for co-ordination, work assignment, fund allotment, report review, and for the overall departmental phases (9). A Technical Flood Control Review Board consisting of a soil conservationist, a forester, an economist, and a hydrologist was created under the Flood Control Office to consider the report for their technical soundness and relation to policy, and to recommend revisions. The Washington Co-ordinating Committee became and advisory committee and the various field committees were disbanded. Surveys were assigned directly to one of the two action agencies, depending upon local circumstances, with practically full responsibility for the survey and the preparation of the final report. Party members were assigned to the surveys from the participating bureaus but administratively were under the direction of the agency, in charge of the survey.

In this re-organization, responsibility for the PE activities remained with the B.A.E. on the

grounds that this was a general planning function. Technicians needed for PE or survey work were detailed from the co-operating bureaus to the agency having charge of the activity.

In announcing the new organization, the Secretary stressed the need for co-ordination between agencies and for uniformity on matters of policy, procedure, and technique. This organization continued to the close of activities, June 30, 1943.

Survey Evaluation Problems

A comprehensive outline of the material which might go into a survey report raised many questions such as the following: What constituted flood damages and what benefits could be claimed under an upstream program? What is the direct relation between improvement of soil and cover upstream and alleviation of damages down stream? How intensive should land use plans be? To what extent should supplemental engineering works of various types and sizes be included? Should individual measures or measures by land ownership classes be evaluated separately, or should such evaluations be of programs for the entire watershed as a whole or of separate subwatersheds? What measures were directly or indirectly in aid of flood control as against purely upland or conservation measures (5)? What was the relation of the department's flood control program to related work and activities of the Department of Agriculture (10)?

Study also revealed the need of reliable data on land use, cover conditions erosion, and similar elements of the problem. Some information could be obtained by adaptations of sampling methods in common use by foresters, but others required entirely new techniques. Thus there were no known procedures for collecting or analyzing essential data in the fields of hydrology, damage appraisal, evaluation of benefits, etc.

These problems suggested the advisability of beginning work on an experimental basis. Accordingly the idea was advanced of bringing together a small number of carefully selected men to develop techniques and procedures, and then of starting work with competent personnel is not more than 3 typical watershed areas to resolve other perplexing questions as they arose. Scuh an approach would, it was thought, provide the basis for future work and avoid costly trial-and-error mistakes. However, because of a desire to avoid "research" projects and because of other "pressures," 17 surveys were authorized and under way within the first six months.

Inevitable disagreements over the character of the program and its evaluation arose as various parties working under different concepts began to complete their studies. As a result, a number of the early survey reports were laid aside until an acceptable basis for their recommendations could be developed. Revisions of other reports were held up because of various administration and technical disagreements which could not be quickly resolved. A number of surveys were abandoned because satisfactory answers were lacking to the very problems an experimental approach would have helped resolve.

Project evaluations, with the exception of life and social security, must be in monetary terms. Costs and benefits of all measures and practices must be calculated. Reductions in flood and sediment damage, and the estimated increases in incomes to flood plain and upland interests resulting from application of the program, must be translated into dollar values. The "nonmonetary" benefits must be described and if possible expressed in quantitative terms such as number of lives, man-days of employment, etc. All money values must be discounted to present worth to permit common comparison of costs and benefits.

All phases of the survey—land use and land management activities, hydrologic analyses, damage appraisals, rate of soil depletion and upbuilding, crop and timber yield studies—contribute to the final determination of the most feasible program. When one considers that the several physical measures are interdependent and are to be applied at different intensities in different portions of the watershed and with different costs; that in every area many significant and material benefits accrue that are not yet capable of direct momentary evaluation; that present hyrdologic knowledge does not permit completely determining the extent to which individual measures reduce runoff, flood stage, or erosion; that only partial knowledge is available as to where the various products of erosion are deposited; and that thoroughly defensible procedures have not yet been perfected, the problem of a sound and

effective evaluation assumes formidable proportions. However, some of the questions which have plagued evaluation policies and procedures might have been resolved more satisfactorily had the Supreme Court decision in the Denison Dam case come earlier.

Damage Determinations

Some of the more specific evaluation deficiencies appear in the appraisals of damage.

To qualify for a survey a watershed must show evidence of "significant" flood or sediment damages. Such damages may be reflected in records of past floods, debris flows, or harmful sedimentation. The extent to which reliable past damage figures are obtained and how they are adjusted to changing physical conditions and economic development to permit a prediction of future damages, often determines whether or not operations may be recommended.

Damages may be grouped into three broad classes: *direct*—consisting of such items as property losses, income losses due to the destruction of the seed and labor investment in crop production, inventory depreciation, and siltation of reservoirs; *indirect*—consisting of such items as income losses due to business and utility interruptions, traffic delays, and depreciated property values; and *intangible*—such as loss of life, health hazards, and community insecurity.

For all practical purposes the distinction between "direct" and "indirect" value is one of degree. Loss of income to an individual arising out of inability to do business or to earn wages because of flood conditions, is just as direct to him as is damage to land, crops, livestock, or improvements. Costs incurred for flood relief and rehabilitation require outlays just as immediate and direct as those needed to repair damaged property or to replace inventories. Similarly, inability to utilize flood-plain lands more intensively because of frequent yet reducible floods represents a direct loss to property owners and to the local communities who otherwise would be able to enjoy increased income, pay more taxes, and add to the community purchasing power upon which businesses and services depend for existence.

Damages of all three kinds arising from disturbed watershed conditions may accrue both on the uplands and flood plains of the watershed itself, and in the flood plains beyond and outside of the watershed. For example, floods on the Youghiogheny, Monongahela, and Allegheny not only produce damage within their own flood plains but also in the flood plains of the Ohio and often contribute to flood damage in the Mississippi.

Floods and sedimentation affect more than the flood plains themselves. The loss of production from bottomlands hurts the economy of the entire watershed and in numerous instances that of an entire region. Serious adjustments are compelled in agriculture, trade, and traffic far beyond the limits of the flood-flow lines. Navigation far downstream and in harbors may be affected; reservoir storage depleted; pollution and low-water problems aggravated; water supplies jeopardized; community health threatened; transportation services disrupted; bottomland production further curtailed by bank cutting deposition, and swamping. A county, a state, several states, the nation—all may be faced with a vicious combination of shrinking revenues and increased costs for relief, rehabilitation, and reconstruction. The May, 1943, floods which inundated some 4,000,000 acres of bottomland in the Mississippi River basin furnish a striking example of these national effects (11).

The published survey reports lack uniformity and adequacy in treating damages. Thus damages classed as direct in some reports are treated as indirect in others. Indirect damages in some are evaluated in monetary terms, in others the same kinds of damages are called intangible or are not evaluated. In only one report, that for Los Angeles, has any attempt yet been made to estimate the contribution of floods and sedimentation to downstream damages to valley lands and cities below the portion of the major basin under survey.

Benefit Determinations

The Flood Control Act states simply that projects will be considered as justifiable "if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected." Originally this was interpreted to include only projects where the total monetary benefits exceed the total costs, and where the total monetary benefits to downstream values exceed the federal cost of the program. This decision was later modified

to permit recommending projects where the benefits from reducing flood and sediment damage amounted to over 50 cents per dollar of federal cost, provided total benefits exceeded all costs.

Only the enumerated benefits from reduction of flood and sediment damage are included in the decisive program evaluations. Omitted are all other forms of public benefits no matter how directly derived from or closely related to the program. Such benefits may be increased public income from public lands, increased ground-water supplies, decreased cost of purifying water supplies, increased hydroelectric power due to increased stability of flow, reduced maintenance of navigation works, improved commercial or game fishing, etc. The ommission of such benefits from the determining ratio has in several cases resulted in recommendations against a program under the Flood control Act. On the other hand the War Department under the same legislation does not calculate separate flood control ratios as such, although it enumerates the flood control benefits along with all the other public benefits in arriving at the decisive cost-benefit ratio. In some recommended War Department projects adopted by the Congress, the flood control benefits have constituted as little as 10 per cent of the total.

In only one watershed (Los Angeles) have the recognized benefits from flood reduction ever equalled or exceeded the upland or conservation benefits of the program. This holds true even where the flood benefit-federal cost ratios have been very "favourable". Regardless of how much the program is expected to reduce damages, the majority of watershed reports show that the greatest proportion of total benefits accrues to the lands on which the work is done.

A possible explanation of the relative difference between the amounts of flood benefits and upland benefits is that the procedures for evaluating the on-site effects of land programs are better established than the hydrologic and sedimentation techniques used to determine the less obvious downstream effects, particularly from individual measures or for portions of complete drainage areas (5).

One may question whether it is possible to divorce flood prevention benefits from the conservation benefits of a given watershed program. The same measures unavoidably produce both kinds of effects together. "Flood control" measures per se are only watershed improvement measures and their downstream effects are an inseparable part of their total effects. Moreover it is the total cost public and private alike, of installing the watershed program and not just one segment of that cost that makes the benefits possible. The federal money contributed to facilitate a program must be combined with outlays by land operators and other public and private agencies to achieve the desired objectives. Without these private outlays, there could be no program. Even on federal lands, benfits from the program are contingent upon the continuance of federal appropriations under other anthorizations which automatically and simultaneously produce both "on-site" and "off-site" benefits. Thus the most reasonable method for determining the economic feasibility of these multipurpose watershed projects would appear to be in terms of total costs and total benefits.

On such a basis the contribution of each participant bears a definite relation to his share of total benefits. Where no special circumstances dictate otherwise a participant receiving 10 per cent of the total benefits would contribute that share of the total costs. This is a practice which the War Department has adopted for many of its water-control projects and has been used on many other types of comparable public works programs.

Similarly, indirect downstream benefits have seldom been given monetary expression in the watershed programs. Although indrect upland benefits have frequently been evaluated, they are not customarily included in the flood benefit federal cost ratios and are often omitted from the total benefit—cost ratios.*

The more intensive use of bottomlands and the increased income therefrom resulting directly from flood reduction often represent a considerable part of the justification of downstream engineering projects. The benefits from the Kentucky Reservoir of the T.V.A., are almost wholly derived from this source. Yet even in areas where this type of benefit might reasonably be expected, it has seldom been recognized.

Another weakness is the absence from most reports of a monetary expression of the effects of continued deterioration of the soil and its

***The War Department, however, consistently gives monetary expression to the indirect benefits of its projects and includes them in the final ratios.**

cover on future flood damages, the water resources, and upland income. Ease or difficulty of monetary expression of downstream damages and benefits appears also to have been the guiding consideration in describing such values as "direct," "indirect," or "intangible."

It might be submitted that where for any reason no evaluation had been made of indirect flood plain or upland benefits, indirect benefits would be assumed to equal the direct benefits. This statement can properly evoke the criticism that any evaluation, no matter how poor, would be better than an unsupported assumption, and that a 1 to 10 or any other ratio might just as well be employed.

The above assumption can be tested by analysis of various reports. In the Upper Susquehanna report, indirect damages as determined by the Corps of Engineers amount to nearly 15 per cent of the direct damages; by contrast the upstream report recognizes no indirect benefits from its program. Nor is any consideration given to flood or sedimentation damages or to the effect of a program on damages below the New York-Pennsylvania state line. The Los Angeles report, on the other hand, recognizes some in direct benefits, such as reduced fire losses, decreased fire suppression and road maintenance costs, and protection and extension of recreational values.

In its Codorus Creek report, the War Department figure for indirect damages is 100 per cent of the direct; in the Buffalo report, it is 50 per cent. The Department, of Agriculture reports for these watersheds, however, fail to express in monetary terms and direct benefits, although in the Buffalo report the effects of the recommended program on such "indirect" values as increased business income and increased wild life production are qualitatively described.

In the Washita report, flood damages consisting of interruptions to traffic and to light, power, and water supply facilities, the loss in business income, rents, and wages, and the spread of noxious weeds are described but given no monetary value. Although upland erosion is severe on 17 per cent of the Washita drainage and moderate on 25 per cent more, and although the washing of some 22,000 acre-feet of soil from roads causes increased maintenance costs of $111,000 annually no reduction of any of these losses is included in the cost-benefit ratios. Sedimentation damages are also not considered.

The Muskingum report recommends no program under flood control legislation because the recognized flood benefits are estimated at 35 cents per dollar of federal cost even though the total benefits are well above the total cost. No mention whatever is made of the contribution of the Muskingum River to flood and sedimentation problems on the Ohio River, despite the fact that the Muskingum furnishes enough water to raise the stage of the Ohio River by from 1 to 3 feet in time of major floods, and despite the serious sedimentation problem in the navigation channel and appurtenances of that stream. Yet the report recognizes that erosion is so serious a problem as to have already reduced a large area of the uplands below the level of profitable crop production thus causing an estimated annual loss of over $12,000,000, and as to threaten destruction to much additional land by the end of the century. No credit is taken for the replenishment of under-ground water supplies.

The Little Tallahatchie Basin report evaluates indirect damages as 25 per cent of the direct and carries this proportion over into the monetary evaluation of flood benefits. It also evaluates but omits from the total ratio a sum representing the increased income on bottomlands from less frequent flooding, amounting to nearly 30 per cent more of the "direct" benefits. In addition, such "intangibles" as increased stabilized employment, increased recreational values to the Sardis Reservoir conservation pool from reduced siltation, growth of the local dairy industry from improved forage, lowered relief costs, and increased local revenues are described but not evaluated.

The Kickapoo River (Wis.) report accepts the War Department figure for indirect damages as 14 per cent of the direct. "Indirect" flood reduction benefits included in the ratio amount to over 17 per cent or the direct benefits; they do not include an evaluated sum representing an additional 17 per cent of the direct benefits effected by savings in flood losses to fishing, wild life, and other recreational values through reduced flooding and stream siltation. Nor is any recognition given the contribution of the program to solving the serious sediment problem involved in maintaining the dredged and expensive 9-foot navigation channel in the upper Mississippi River, or in the swamping of adjacent bottom-lands. The upland benefits fail to include an estimate for the

appreciable savings in erosion losses. "This benefit is not expressed in monetary terms because methods for measuring the effects of erosion on land productivity are still too inexact."* A similar statement could be applied with equal force to the evaluation of "direct" flood reduction benefits, to wild life and recreational benefits, or indeed to almost any type of benefit.

The St. Francis River (Mo.) report does not include either in the flood or total ratios the amounts evaluated for reduced erosion losses for increased recreational expenditures, or for the increased labor returns expected from the program. It recognizes but gives no monetary expression to savings due to reducing current damages by extensive forest fires and overgrazing, to lowered relief costs, or to the increases in rentals from managed federal and state lands. It does not evaluate benefits from more intensive use of some 5,000 acres of currently flooded agricultural land within the upper portions of the Wappapello Reservoir. Were these lands permanently under water, no benefits would be possible ; but they are now subject only to intermittent flooding. Under an upstream program the hazards to these lands from frequent flooding would be considerably reduced and their usefulness increased.

Enhanced flood plain values constitute over half the monetary benefits in justification of the program for the Trinity River (Texas). The report describes but does not evaluate stabilized streamflow, lessened pollution, increased flood-plain recreational values through greater flood protection, and increased safety factor for existing levees now periodically damaged by flood flows, reduced traffic delays, increased recharging of ground water and hence increased well-water supplies, reduced cost of public services through less road damage, decreased sedimentation, etc.

Although outstanding consultant hydrologic engineers were employed to help, with troublesome hydrologic problems, the same procedure was not followed in the economic field even though many opportunities presented themselves for resolving such difficulties with the aid of nationally recognized leaders in economics and evaluation.

Evaluation of Measures and Programs

The manner of evaluating the measures and programs for the several portions of given survey areas gives little support to the unified watershed concept.

The first upstream report (Los Angeles) contains separate monetary evaluations for each forestry measure both for the entire watershed and for each tributary drainage. These measures included debris barriers, mountain channel improvement, slope stabilization through improvement of cover, road-erosion control, fire protection, and reseeding of newly burned over areas. The assumption behind this method of evaluation was that the physical effects of each individual measure were independent of all others and therefore the damage-reduction benefits from each one could be realized regardless of whether or not any or all of the other measures were installed. A difficulty arose with fire protection where for some small subareas the federal cost was calculated to be more than the flood reduction benefits received from those areas. As it was apparent that no upstream program in the southern California chaparral type would be feasible without adequate fire control, the necessity for installing it over the entire watershed was conceded.

This experience led to more careful consideration of the mutual dependence of the several measures comprising watershed programs. As a result but few subsequent reports have utilized such detailed cost-benefit ratios or separate ratios for individual cropland measures, pasture measures, and woodland measures within operating farm units. However one report, involving western rangeland, recommends a program including a reduction in livestock, artificial reseeding of critically depleted range, and small debris-control works. Designed as the most feasible of several alternatives, it was found to produce the largest amount of net benefits. Nevertheless exception was taken to the reseeding measure on the ground that its individual federal cost exceeded its individual flood control benefits and that therefore it should be omitted. This despite the fact that the benefits of range management as a whole were calculated as more than the costs and more important, that without the reseeding program, further range deterioration could be expected even with other measures installed.

*For one method of evaluating the capital losses caused by soil erosion, see Bunce and Collier (2).

Such reasoning has been confined almost without exception to range and forest land programs. It presumes that the principles of unified land management are peculiar only to farm enterprises. Yet wildland operations are just as complex and interrelated as farm enterprises. That there is need for detailed scrutiny and appraisal of each and every part of a given operaition is not questioned. But when conclusion fail to consider the relation of the several parts to the operations as a whole, they lose their perspective (4).

Several survey reports get even farther away from the unified watershed concept. In some the programme for each land ownership class within each tributary area has been evaluated separately. Thus if a drainage has five units, each containing farmlands, private forest lands, and public lands in different proportions, 15 separate ratios would be prepared and operations recommended or not recommened for each class of ownership in each subdrainage according to whether each ratio was "favourable "or "unfavourable."

The report on the Coosa River watershed (Ga.) follows this principle. The basin is broken down into 6 subwatershed units, 4 of which are sub-divided by 3 patterns of ownership and the remaining 2 by two types of ownership. Thus 16 different ratios are presented. A program under the flood control legislation is recommended for only those types of ownerships in the various independent subdrainages where flood benefits are more than 50 per cent of federal costs.

The Washita watershed report follows a different policy, although it similarly presents ratios for two types of ownership on 7 of the 9 subdrainages. An entirely different principle, however, is followed in their application. The farm program on 4 of these subdrainages provides benefits ranging from 23 to 34 cents per dollar of federal cost and, in the case of the public land program, benefits of from 4 to 39 cents per federal dollar of cost. Nevertheless a complete program for the entire Washita basin regardless of type of ownership or subdrainage was recommended under the Flood Control Act. The justification for this was that the total of all benefits in each subwatershed, for each type of ownership, and for the Washita as a whole was greater than the total costs.

It is evident to those versed in land management that in most cases the economic and biological interrelations among land classes within a given area, such as farm and non-farm lands, private and public rangelands, etc., make their separate consideration questionable. Thus where farmers are dependent upon woods work for supplemental income, or where stockmen depend on their own lands for winter forage and on public lands for summer range, a program that considered each category as a separate, unrelated entity would not be sound nor capable of effective administration.

Two other items directly concerned with evaluation pertain to the application of interest to non-cash outlays and to the selection of discount rates for cost-benefit comparisons.

A common practice has been to treat current or deferred farm labor costs as cash outlays, and to charge them with interest. Farm economists, however, believe that such costs should be charged as cash only where there is an actual increase in hired labor costs or where the labour of the farmer and his family lessens the possibility of earning income from other sources. They also warn that many faulty conclusions are reached when it is assumed that all of the labour spent in agricultural production is of the same value per unit. The ultimate measure of return is held to be the farmer's income from the enterprise as a whole, and this is the basis for his acceptance or rejection of proposed changes in practices. In short, unmarketable items should not be given a dollar value (2, 4).

The calculation of financial cost-benefit ratios requires that all expenditures and benefits be reduced to a common time level such as "present value" or "average annual equivalent." By this process costs or benefits occurring at varying rates in the future are naturally less in amount when brought back to the present. The application of this discounting process to private borrowers and other individuals is self-evident.

The watershed reports, with but few exceptions, have applied identical discount rates to the public and private features of watershed programmes. This use of a common interest rate for calculating present worth was designed to save the extra labor entailed in using variable rates for the different financial sources or beneficiaries. The most common compound interest rate employed is 3·5 percent or from 1 to 1·5 percent higher than current government borrowing rates and higher than rates used by

other federal agencies in evaluating comparable programmes[6]. Naturally the higher the proportion of public costs, and especially benefits, the greater is the error involved in employing the common rate.

Some economists even question the use of discount rates at all under certain conditions of conservation enterprise (3). Foresters are well aware that the use of compound interest formulae in calculating costs and benefits from rebuilding naked lands requiring costly treatment and a long restoration period will in most cases show such undertakings to be unjustified by common financial standards. Yet society is definitely interested in developing the watershed values in such lands and in preventing soil and water wastage from them. The transformation from "poor land and poor people" to productive land and healthy, energetic people still defies adequate evaluation by any monetary standards so far devised. Yet there is little question of the local, regional, and even national benefits so derived (7, 8).

Perhaps if the various economic and social values could be expressed in monetary terms the discounting of all benefits might be warranted. But until we develop a more universal evaluation approach, we cannot avoid making some provision for weighing them, either by eliminating the discount rate under certain conditions, by allowing for indirect and "intangible" benefits, or else by recognizing that "economic feasibility" is only a partial criterion for justifying projects of major public interest.

A possible clue to fair appraisal of the value attached to watershed protection is the record of actual land purchases for this purpose. Many small drainage areas have been purchased by municipalities, water districts, water companies, and manufacturing companies in order to assure safe and ample water supplies (13). These often have not been worth the prices paid as judged by current market standards, but the communities are private enterprises concerned have recognized other values (1). In their purchases "nuisance" values have been recognized both in voluntary transactions and in court condemnation proceedings. Such cases reveal that the necessity for safeguarding water supplies is often great enough to warrant expenditures over and above those warranted by purely financial considerations alone (12).

Aids to Programme Installation

In many drainage areas, the degree of cooperation anticipated in carrying out the program determines its feasibility. The private owner will do many things if it can be shown they are directly to his financial interest. When not to his interest the public must utilize other devices which may not in themselves provide any flood control benefits yet are essential to the success of the program. Probably the most important of these is public acquisition. Here a change in land ownership provides no flood control benefits *per se*, although in most cases public ownership yields many other financial returns which accrue directly to the public benefit. None of these auxiliary public benefit, however, have ever been recognized in determining whether the program should be recommended under flood control legislation, although the full purchase price to the federal government has been included along with the cost of treatment in the determining evaluation.[7]

In many watersheds the remedial programme cannot be a success unless the critical sources of flood and silt are treated and are provided with continuing management in the public interest. In many cases such as on poor submarginal land, neither the requisite and often costly treatment can economically be undertaken by private interests nor can continuing management and protection be assured. This is illustrated by the extent of tax delinquency of denuded lands and the failure of many owners to provide even a minimum control for them. Public ownership is therefore recognized as the most effective, if not the only, guarantee that the money spent for installing a program in such areas will not be lost through subsequent failure to protect and especially to maintain the measures year in and year out.

[6] Interest rates are 3·0 per cent in the Los Angeles, Buffalo, and Muskingum reports; the St. Francis report applies a rate of 2·5 per cent to federal costs and 3·5 per cent to all others: the Trinity report uses 3·0 per cent for federal costs, 4·0 per cent for state costs, and 5 per cent for private costs.

[7] The inclusion of the entire land purchase cost in the total federal cost follows the practice used by the Army Engineers when evaluating a reservoir. This practice on their part is defensible since the land occupied by the reservoir is permanently taken out of all other uses and provides no other benefits. By contrast, the land publicly acquired under a Department of Agriculture programme provides continuing public benefits almost from the time of purchase.

The several reports have handled public land acquisition in various ways. The Los Angeles report recognizes the need for federal acquisition of certain key private holdings as basic to adequate control of mountain lands but does not include the cost in the recommended programme.

The Buffalo watershed report recommends state acquisition but provides that the federal government will contribute towards the purchase price a sum equivalent to the amount of the flood benefits estimated to result from that part of the programme. By contrast, a public purchase programme is found necessary in the Upper Susquehanna drainage but the entire acquisition cost is charged to the state, with assistance from the federal government only after the lands have been acquired. Thus within the same state, two different policies of purchase cost allocation are pursued.

The Washita report takes a still different approach. Here, despite the fact that the flood benefits stemming from federal acquisition throughout the entire area and in each of the 6 tributaries are in every case far below half the federal costs, this land purchase programme is recommended as favourable under the Flood Control Act along with the separately evaluated farm programme.

Two different ways of handling acquisition are contained in the Little Tallahatchie report. Private lands needing treatment and located within the external boundaries of the present national forest are recommended for purchase under regular departmental (Clarke-McNary Act) appropriations. Elsewhere, the costs of all public purchase and private land measures are combined in each tributary area, the total flood benefits found to exceed the corresponding federal costs, and the entire programme recommended. But in the Trinity River watershed, which also contains already established federal purchase units, the report evaluates all public and private lands together for each tributary area.

The St. Francis report also combines the evaluation of public and private lands, but recommends no action under the Flood Control Act because the flood benefits as calculated are less than half the federal costs, although both the ratio of all public costs to all public benefits and the over-all ratio are favourable.

Another prerequisite to the success of the flood programme has yet to be mentioned in the upstream reports. The 1937 amendment to the Flood Control Act states that as a condition to extending benefits the Secretary of Agriculture may require: "(1) The enactment of reasonable safeguards for the enforcement of State and local laws imposing suitable permanent restrictions on the use of such lands. . . . (2) agreements and covenants as to the permanent use of such lands." In other words, he can require that assurance be given for the safety of the programme. This appears possible only through some form of public control which would guarantee maintenance over a considerable period.

So far, the exercise of this power to maintain the measures installed on private lands is not required of the local public. As covenants must be recorded locally and run perpetually with the land, the possibility of their use on any extended scale is highly questionable. How far local restrictions and public control could be utilized over any extended period and with changing economic conditions is a moot point. This lack of required maintenance causes real concern as to the continuing value of the programme applied to private lands. Few reports recommend funds for continuing supervision.

Summary and Conclusions

Foresters have for 50 years held that floods and sedimentation reflect improper watershed conditions. National forests have been set aside from the public domain and lands have been purchased in recognition of this belief. Fire control and reforestation programmes have been adopted as part of a watershed protection plan. Now, other beliefs are encompassed in flood control legislation, and adopted projects under it are demonstrating the validity of one of their tenets of faith.

Progress under the Flood Control Act is recorded in the completed reports. That these are not all of the same quality or contain comparable evaluations reflects some of the difficulties in developing a new programme. Judged on the basis of the handicaps overcome and recognition obtained, the marked progress that has been made, attests to the belief and faith in the programme held by many who participated in it. Judged only by the number of printed reports, progress has been small considering time and effort expended, and the results are not too impressive. That there has not been

greater achievement is due to many causes such as initial overconfidence, lack of suitable techniques, inadequate knowledge as to the effects of land treatments on runoff, considerable administrative floundering, and early failure to recognize the many administrative and technical problems inherent in a complex programme of this magnitude. Had a more critical approach been taken in its early stages, some of the disappointments might have been avoided.

The printed reports reveal many major defects such as insufficient attention to evaluable flood and sedimentation damages and to corresponding benefits; failure to weight the unevaluable losses from flood waters and sediment or the benefits from reducing such losses; inadequate consideration of the beneficial effects of good forest cover; incomplete information on runoff relations; over-emphasis upon separate evaluations of costs and benefits for individual measures and land ownership classes comprising biologically and economically interdependent parts of unified watershed operations; minor consideration of upstream benefits from watershed programmes ; failure to recognize auxiliary public benefits ; complete dependence upon financial cost-benefit calculations in determining the technical and economic feasibility of watershed operations; inadequate evaluation of the otherwise recognized effects of continued deterioration of soil, cover, and water resources upon future flood plain and upland damages; inconsistencies in recommending for or against specific operations programmes under flood control legislation.

Nevertheless, some outstanding achievements can be cited. They include such things as the development or better understanding of basic watershed principles; improvements in techniques and procedures; more effective co-operative relations with other federal, state, and local agencies; a noteworthy contribution to the planning and operations features of post-war public works.

For example, the large-scale investigations have clearly brought out the dominance of erosion-caused sediment in the flood problem. Such damage, in contrast to damage by flood waters alone, is far more lasting—sometimes permanent—and often requires costly restorative treatments Proper watershed treatment, on the other hand, can prevent many of the costs and losses due to dredging and bank caving. This knowledge has stimulated appreciation of the need for more thoroughly evaluating the role of watershed improvement, and particularly of day-by-day mangagement, in reducing sediment damage. Thus attention has been focused on the value of such practices as fire control, grazing management, and road stabilization, not solely for cover maintenance but primarily for direct control of destructive water and debris flows.

Another finding has been that the smaller, more frequent floods on the lesser tributaries—floods most susceptible of reductoin by watershed operations—generally cause greater losses in the aggregate to agricultural lands and crops than the larger more spectacular floods on the main streams. Because most flood storage and multi-purposes reservoirs are located on or close to the larger streams and below many tributaries, the value of upstream programmes assumes additional importance. There is danger, however, that so much emphasis may be placed on the smaller streams that the value of the upstream programme to downstream values along the main stream and to regional flood problems may be minimized.

The upstream programme has also demonstrated the value of good cover conditions in controlling soil and water. It has shown that we have yet to go a considerable distance in fire control and in preventing land and cover abuse. It has provided a technique whereby land management can be appraised in terms of the greatest good to the greatest number. It has demonstrated the value of transpiration in maintaining the soil as a flood storage reservoir, and of humus in increasing and preserving the storage capacity of shallow soils. Although specific results apply only to certain watersheds, they are of such significance as to give greater impetus to the development of practices which beneficially influence the water relations of forest growth.

The surveys have definitely stimulated advances in hydrologic procedures. Progress has been brought about by the need to trace the sources of damaging flood and sediment flows in upland characteristics and culture. Other advances include procedures for measuring the effects of evaporation-transpiration rates from various cover types and conditions on flood volumes, methods for measuring infiltration and suspended silt load, and methods for determining the relative contributions of sediment and debris from sheet erosion, gullies, roads, streambanks, and channel beds.

These advances in procedure have also focused attention on deficiencies in hydrologic data. Not only is there a dearth of precipitation-intensity and streamflow measurements, but the usable information on the effect of different cover conditions on runoff and erosion is pitifully scant and usually available only from small plots. Apparently foresters have long aired their beliefs without taking measurements to substantiate their case.

The programme has brought about a greater realization by many land operators and by public land administrators of the specific, quantitative relations between land use policies and practices upstream and damage and protection problems downstream. It has shown them the need for constant watchfulness lest the soil and its cover deteriorate under practices which can be so easily condoned or excused. It has also helped to bring closer together the thinking of engineers and conservationists in their respective approaches to a common problem. Engineers have come to appreciate the limitations of levees and other structures in meeting the flood problem and now look to watershed measures as a further aid. The attitude of conservationsists on this point is well expressed in the report of the Secretary of Agriculture for 1943:

"Extensive watershed measures will be essential also; but these likewise cannot be expected to accomplish their effects immediately. Certain benefits will accrue quite soon from the protection of soil and vegetation. In most cases some effects of proper land management should be evident within a very few years. These will include increased crop yields, more and better pasturage, and more productive forest growth. Erosion losses will decrease comparatively quickly.

In forest areas results will become apparent within a few years, but a long period may elapse before the maximum effect is obtained. In order to achieve the greatest possible benefit in the shortest possible time, it is essential that the upstream and downstream phases of flood control be properly timed and co-ordinated, through the development of one over-all plan for each of the major flood-contributing watersheds.

In part the lack of integration between the watershed and waterway features of flood control is due to the fact that downstream flood control programmes have long been accepted and projects completed before the land phase was recognized. It is also due to insufficient recognition of the unspectacular land programme, to the lateness of its start, and to the slowness in achieving results. Engineering works and structures, effective though they are, do not meet the problem of preventing damage at the source. The disasters of the past few years have demonstrated also that they do not provide the complete answer. The recognition of the latter plus the need for protecting large-scale investment in such works will undoubtedly furnish additional reason for greatly expanded watershed operations. It is therefore believed that future investigations will provide greater opportunities for joint consideration and evaluation of upland and downstream problems and for joint undertaking of the necessary operations.

The programme of upstream surveys has helped to focus the attention of conservationists, engineers, and economists on the importance and desirability of unified watershed treatment and management. Many engineers who formerly were sceptics, now are accepting the idea of upstream control. Since the programme began, more discussion of the role of land and its cover in flood control has appeared in engineering journals than in forestry magazine The fact that upstream work is now becoming accepted and that the flood problem is so serious make it more than likley that further watershed investigations and operations will be undertaken after the close of present hostilities.

It is believed that the upstream programme has suffered more from neglect than from adverse comment. It ought to have the constant and careful attention and continuing scrutiny of its supporters to keep it on the soundest possible basis, to overcome its defects, and to ensure the best approach. Such current review is also necessary to aid in establishing and developing the best policies and techniques, to assure desirable evaluation processes, and to make certain that control practices and programme are of the best. Much more concern should be evidenced by state and private foresters especially as to the over-all character of the problem and as to the regional and national aspects of its solution.

No one who studies the watershed reports will get the impression that the recommendations are extravagant. One finds little evidence of over-optimism, but rather the opposite. The

insufficiency of damage appraisals, shortcomings in admitting many benefits, the common omission of public auxiliary benefits, the cautious hydrologic approach, the application of evaluation procedure—all these tend to make the programme conservative. Such conservatism might only be a temporary condition until the programme has received wider recognition, but lack of public comment raises the question as to whether there is any general concern over its present shortcomings.

Present concepts, especially in the evaluation processes, need thoughtful attention. The nature of the watershed problem is such, and the application of scientific techniques on the large scale required is so new, that we cannot rely exclusively upon the results the mathematical calculations derived from the limited and approximate findings of physical scientists and economists. There is every reason to believe, however, that such calculations can be extended in the best interest of the programme.

In order to accomplish these various ends the active support of all foresters and conservationists is urgently needed. We must achieve a better understanding of the role of land in the control of soil and water movement, establish policies that recognize the fundamental biologic nature of the watershed process, and help apply these policies in a balanced and consistent manner.

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WHY DOES THE DESTRUCTION OF TREES THREATEN TO TURN A COUNTRY INTO A DESERT?

(Talk over A.B.C. National Network by B. Farrell, Divisional Officer, New South Wales Forest Service, Australia)

To provide food and clothing, man has had to fell and burn much of the forests, to make way for pasture and cultivation. Up to a certain limit no one would question the necessity of this. But indiscriminate destruction of trees can have a damaging, and even disastrous effect.

In the areas of higher rainfall, although rockless clearing of land can cause grave loss of soil fertility, its most serious effect is on the flow of the rivers, many of which are the lifeblood of inland areas.

On the steep mountain slopes, the roots of the trees form a binding network in the soil with the undergrowth and fallen leaves and debris, and with the canopy of leaves to break the force of the rain, the soil is held safe against the heaviest deluge. The water seeps through the soil and comes out in springs and small streams—slowly, so that the streams run steady and clear.

If the trees on these steep slopes are cleared and burned, the rain beats unchecked on the exposed earth, and rushes unhindered down the slopes, taking earth and stones with it. The once limpid streams become rushing, muddy torrents. When the rain stops, the torrents cease to flow, the floods recede and the streams dry up.

The rivers become silted, and their flow becomes seriously deranged. In the Murray, which has a winter rainfall, the summer flow fell in 50 years from 30 per cent. to 16 per cent. of the total, following clearing, burning and overgrazing of much of the catchment area.

Spread around the Earth's surface there are several large dry and barren areas where very little life of any sort exists. These areas are the deserts of the Sahara, Kalahari, and so on. They all lie in the same latitudes, and in somewhat similar climatic conditions, to the interior of Australia. Over at least some of them, although conditions favoured the for mation of deserts, there was originally vegetation and surface water. The change has been brought about by man.

We must remember that, geologically, the earth is at least 750 million years old, and that vegetation has been 60 million years eastablishing itself, and reaching a state of balance with the rest of nature—a balance which, in the areas we speak of, hung on a very fine point indeed. Man has existed for about a million years, and civilised man, with farms and flocks, for about four thousand years. In Australia,he has been improving the earth's surface for only 150 years.

What has man done, in these drier areas, in his 4,000 years of civilisation? Let us look at North Africa and Eastern Mediterranean.

Nineteen hundred years ago, this part of the Roman Empire was fertile, with forests and cornfields and flowing streams. Now it is largely a barren, deserted wasteland. Once it fed a large, highly cultured population. The presence of huge architectural ruins is mute testimony to this. Now a few nomadic Arabs are all it can support.

What happened? Well, first let us look farther south, at the Sahara itself. In the heart of the Libyan desert, at the eastern end of Sahara, rock paintings of domestic cattle, and other evidence, show that once a settled population lived there. There is more recent evidence in the works of old Arab Historians. In 1496, a local Arab ruler made a pilgrimage to Mecca. He travelled from near Timbuktu, on a route 400 miles north of Lake Chad, taking with him his wives, 800 slaves and a large number of camels, horses and donkeys. To-day he would have to take the camels, and leave behind the horses and most of his followers.

What happened then ?

Let us move a few hundred miles south and we shall find the process still going on, the desert encroaching southward. First, the native tribes carry on a shifting cultivation, clearing and burning the forests, working out the soil, moving on. The forest soils become too impoverished for cultivation, and nomadic graziers take their place with cattle, burning

each year for grass, destroying more trees; the land deteriorates further. The cattle are replaced by sheep and finally by goats. By this time the trees are few and scattered, and ground herbage has disappeared. Lopping for fodder kills the few remaining trees. The soil has become shifting sand. Man moves out, and the desert moves in.

The key to the story is the destruction of the trees. In the dry areas, the trees shelter the soil from drying and eroding winds and conserve the soil moisture. With their deep roots they can survive the periodic droughts. When the trees—and here I must include drought-resisting perennial shrubs such as saltbush—are destroyed, the grasses and other annuals which take their place may hold the soil in good years. But when the drought years come, they die. The soil is naked, dried out, defenceless. The wind winnows out the fine particles, the fertile part of the top soil, and carries it away in great dust-storms. You may think of this next time the dust-clouds appear over Sydney. Six inches of soil may disappear in one drought year. What is left is coarse unfertile sand. The fine soil which was blown away was formed there over thousands of years. It will take that long for it to form again, if it ever does.

In our own State of New South Wales, the most critical area is the Mulga and Saltbush country. Over vast areas of the Mulga, more than half the standing trees are dead. The old trees are dying or being killed, partly by care less grazing or lopping for fodder, partly by rabbits. There are no young trees to replace them—the seedlings are trampled or eaten by sheep and rabbits. The Mulgas and other trees which are left are often held by their roots six inches or more above the ground. The soil has been blown away.

In the saltbush country, much the same story is told. The Old Man Saltbush is being destroyed by rabbits, by overgrazing and finally by wind erosion. Over large areas it has disappeared altogether.

The skeletons of dead Mulga and Saltbush would hold the soil for a few years, but even they are soon trampled and broken up by stock.

The sand which is left when the fine soil is blown away forms into dunes. It is in this way that the desert encroaches, not by the movement of sand dunes from the older desert.

What causes the destruction of tree cover in these areas where it is so vital? There are, no doubt, underlying social and economic causes, but the immediate causes are indiscriminate clearing, careless grazing, repeated and often deliberate burning, and uncontrolled bush fire. The remedies are not easy; they call for clear thinking and a sincere and dertermined approach. We must conserve our resources instead of plundering and destroying them.

The Bush Builder, Vol. 2, No. 3 dated March-April, 1945.

VOLUME 72 NUMBER 2

INDIAN FORESTER

FEBRUARY, 1946

MANAGEMENT AND IMPROVEMENT OF GRAZING IN WASTE LANDS OF THE UNITED PROVINCES*

BY K. D. JOSHI, I.F.S.

(*Divisional Forest Officer, Afforestation Division, U. P.*)

FOREWORD.—The management and improvement of grazing in the waste lands of these provinces is an integral part of post war planning, having been provided for in the proposed programme of post war reconstruction in the U.P., which includes a large-scale scheme of land management covering the whole of the U.P. (excepting the hill *patties* of Kumaon). There seems little doubt that one condition essential to the success of any scheme of grazing regulation in *zemindari* lands is the co-operation of the local population. For this reason it is envisaged that as far as improvement of grazing and fodder resources is concerned, only the simplest and least restrictive schemes of regulation are really suitable for initial application. More complicated schemes involving a greater degree of restriction are both difficult and unpopular from the point of view of the villagers and inevitably lead to evasions. Such research as has been done in improvement of grazing in this province clearly points to the primary necessity for periodic monsoon closures to afford annual and perennial grasses an opportunity to recuperate and to sustain themselves. Biennial monsoon closures for three to four months (*i.e.*, closing half the area in the rains on a two years' cycle) therefore appears to be the most suitable for initial introduction on an extensive scale. Partial closures in the rains are moreover more convenient from the point of view of villagers, since any restrictions on pasturage are felt least keenly at that time. The following detailed note on this subject by the Divisional Forest Officer, Afforestation Division, U.P., summarizes the work undertaken in this province under this head.

E. W. RAYNOR,
Conservator of Forests,
Working Plans Circle, U.P.

The various methods of grazing regulation which have been attempted in the afforestation division, U. P., are described below. All are based upon a limiting incidence of grazing equivalent to 2 acres per cow:—

I Periodic grazing

(*a*) Annual closure of the whole block for two months in the rains (July and August) every year, the pasturage being available only for the remaining 10 months—one year cycle.

(*b*) The grazing block is divided into 3 more or less equal sub-blocks, two of which remain closed in the monsoon and one remains open in the same period. In the winter and summer (*i.e.* the remaining 10 months), two sub-blocks are opened, while one sub-block is kept closed for 12 months; the whole arrangement in rotation—3 years' cycle.

(*c*) The grazing block is divided into 2 sub-blocks, one of which remains open in winter and summer, while the other remains closed throughout the year. The whole block is completely closed in the rains (July to August) every year—2 years' cycle.

(*d*) The grazing block is divided into 3 sub-blocks, one of which remains open in winter and summer while the other two are kept closed. The sub-block opened in winter,

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*Paper presented at the 6th Silvicultural Conference, Dehra Dun (1945), on item 6—The Afforestation of Dry and Desert Areas: Communicated by the Conservator of Forests, Working Plans Circle, United Provinces.

however, is closed during the rains (July and August); the whole arrangement in rotation—3 year's cycle.

(*e*) The grazing block is divided into 4 sub-blocks, of which only one remains open in the rains while the other three are opened in winter and summer, the whole arrangement in rotation—4 years' cycle.

(*f*) The grazing block is divided into 4 sub-blocks only one of which is opened in the rains and two in winter and summer. The fourth remains closed throughout the year; the whole arrangement in rotation. This is slightly different from (*b*)—3 years' cycle.

II Rotational grazing

The grazing block is divided into 4 compartments each of which is open for one month and closed for four months in rotation fifth and ninth month every year. This was abandoned in 1943 when found to be incapable of enforcement in practice.

Results of various schemes of grazing regulation as practised in the afforestation division, U.P.—It has been proved without doubt that closure to grazing for only a few months during the monsoon, improves the quantity and quality of the fodder grasses while the indigenous tree and shrub-growth also benefit by protection. Fodder grasses of better quality (both perennial and annual) get a chance to recuperate, to seed properly and to regenerate and to extend naturally, while surface erosion is definitely arrested by one year's effectual preliminary closure followed by rains closures.

(*ii*) Grazing in winter and summer (dry) months does not have any marked injurious effect on the growth of grasses, provided the limiting incidence is not exceeded.

(*iii*) The limiting incidence of grazing aimed at is two acres per cow or bullock, one buffalo being counted as two cows or bullocks. Even this limiting incidence may be too intense for poorer soils and terrain.

(*iv*) Grazing under control combined with rains closures, followed by one or more cuttings of grasses does not result in any appreciable deterioration in quality and quantity of the grass yield.

Comparison of methods not feasible at this stage.—It is necessary however to emphasize that it is impossible to make a fair comparison between the various methods of grazing regulation tried and to draw tenable deductions from their results, because (unfortunately) the incidences and closures prescribed can seldom be effectually enforced in practice, owing to lack of proper fences and to evasions on the part of local staff and villagers, thus obscuring the differentiation of results. *Tenable deductions as to preference of method cannot therefore be adduced at this stage.* We can say definitely however that it is obvious that no method or scheme can have a hope of success without the full co-operation of local village *panchayats* and, initially, we can only hope to arouse their enthusiasm by introducing the simplest possible method involving the least possible restrictions upon local usage. Until the villager becomes educated in this matter, more complicated schemes can have little hope of success.

Agency for future management.—There is also no doubt that in view of the existing and long-standing apathy on the part of both *zamindars* and villagers, the only possible solution lies in the state assuming control of neglected lands. As soon as *zamindars* and villagers become convinced of the value of grazing regulation in producing better and superior fodder-grasses for their cattle, both for pasturage and stall-feeding, the state could relax its control in favour of the local public. A stage has now been reached when the problem of introducing some form of control of grazing can no longer be neglected for the greater good of the greater number. Not only is erosion steadily eating into valuable culturable land but the standard of draught and milch cattle is fast deteriorating for lack of adequate nutrition. *Zamindars* and villagers have yet to learn the value of arresting further erosion of their lands and of providing better pasturage for their cattle under state guidance. With propaganda, persuation and patience, large areas can however be brought under effective control with immediate success.

THE AFFORESTATION OF DRY AREAS IN SIND *

By J. PETTY, M.C., O.B.E., I.F.S.

(Lately Conservator of Forests, Sind)

The Fixation of Shifting Sand

Prosopis glandulosa was introduced near Hyderabad (Sind) late last century for the fixation of shifting sands and has proved fairly successful. It has not spread extensively except within about a 15 miles' radius of Hyderabad. A few plants, however, were noticed in the hills 30 miles from Hyderabad at an elevation of about 1,500 ft. which appeared fairly healthy though the average rainfall is only 7".

Irrigated plantations

A description of methods of raising irrigated plantations in Sind is given in paras 10-14 of "Note on a tour of inspection of the Sind forests" by Sir Herbert Howard, Inspector-General of Forests, published in December, 1943.

"10. *Inland forest, class (b) i.e.* irrigated by either barrage canal water or inundation canal water in addition to the water from floods or from occasional breaches in the protective *bunds*. It is regenerated by the agri-silviculture (*taungya*) system. It is all still largely experimental but at present, though many species are being tried, the main species is *Acacia arabica* (*babul*) with some mulberry. The eventual rotation will probably be 15 years and available figures show that this will produce a mean annual increment of at least 100 cft. per acre of fuel and small timber, the fuel being excellent for producer gas charcoal, the timber being suitable for the requirements of the ordinary agriculturist and with possibilities of using the bark for tanning.

11. There have been doubts expressed whether *babul* will grow in upper Sind. As it grows perfectly well both in lower Sind and over large areas in the Punjab to the north, there is no reason at all why it should not grow in upper Sind except in those few places where frost is excessive. At any rate, it is now being extensively introduced and seems to be doing very well. It is true that in upper Sind only inundation canal water is available and the *babul* likes water, but even if *babul* cannot be grown, *Prosopis spicigera* which grows well still gives a mean annual increment of 50 c. ft. per acre.

12. The cultivators are allowed either one year's cultivation prior to putting in the forest crop followed by four years' cultivation with the forest crop or they put the forest crop in with their own field crop straightway and are then allowed five years' cultivation. This depends on whether the land needs prior levelling. They cultivate either a cash crop like cotton or a food crop like *bajra* and at the present moment, in order to increase food supplies in India, are being forced to cultivate food crops in some areas where they would prefer to cultivate the valuable cash crop, cotton. Naturally this has some effect on finances, the forest department getting less financial credit out of such areas than it really deserves. The *babul* is sown in lines either 33 ft. or 40 ft. apart and experiments are being made with an additional line of trees midway between the main lines. This line is usually raised during the fourth or fifth year of the rotation. Experiments on the best methods of formation and the correct distance are still going on. Nor is *babul* the only species, mulberry is quite common, especially for the intermediate lines. The mulberry are carefully pruned when about 8 feet high to get at least 6 ft. bole perfectly and clean and knot-free timber.

13. With such work as this, complicated financial forecasts are unnecessary and are apt to be misleading. But a few figures are not out of place. This forest, before the introduction of this conversion to regular plantations, was in fact giving not more than eight annas per acre per year gross revenue. One cusec of water is sufficient to irrigate 70 acres with barrage water and about 35 acres with inundation water to a depth of from 3 to 5 feet. This costs Rs. 300 per year for barrage water and Rs. 100 for inundation water or just over Rs. 4 per acre for barrage water and nearly Rs. 3 per acre for inundation water. Taking pre-war prices, the forest department received an average of about Rs. 25 per acre each year for leasing the cultivation irrigated by barrage water, where cash crops can be grown, and about Rs. 12-8-0 per year for cultivation

*Paper read at the Sixth Silvicultural Conference, Dehra Dun (1945), on item 6—The Afforestation of Dry Areas.

irrigated with inundation water. Thus, the immediate income from five years of cultivation more than pays for the water for the whole 15 years of the rotation, besides establishing the *crop for nothing*. Incidentally where *babul* can be grown even the pre-war value of the expected yields of 100 c.ft. per acre per annum is worth Rs. 10, while even assuming that upper Sind can produce nothing better than *Prosopis*, the 50 c.ft. per acre per annum expected from that was worth at pre-war rates Rs. 5. While figures might be produced to show that even greater profits might be obtained if the area were entirely converted from forest to agricultural crops, the figures in fact would be misleading because it is the great fertility of these forest soils which leads to the high prices paid for the short cultivation leases. Prices being paid at present are of course fantastic, averaging Rs. 100 an acre for a one year lease in the barrage canal irrigation areas and Rs. 20 to 40 for one acre in the inundation canal irrigated areas."

The Sind plantations are only in their infancy and there is still much to be learned. Amongst the problems upon which research is required are:—

(*i*) The minimum quantity of water which wil yield an outturn of at least 100 c.lft. of wood an acre a year.

(*ii*) The best irrigation methods (*e.g.*) what should be the width and depth of the irrigation trenches, should they be dug alongside the trees or midway between the tree lines; at what intervals should watering be done etc., etc.)

(*iii*) The area of plantation that can be watered and tended by one forest guard or *mali*.

(*iv*) What modifications of technique are necessary to avoid "Wilt" disease which has appeared on a small scale in one area.

(*v*) What better fodder grasses (*e.g.*, giant star grass) can be established without exhausting the soil fertility.

(*vi*) What exotic timber trees can be grown in Sind. Particular attention to be paid to *Acacia mollisima* and *A. decurrens* (which yield wattle bark,) the cricket bat 'willow', the light hardwood, etc.

SOME HINTS FOR SEED COLLECTORS

By Jagdamba Prasad, B.Sc., LL.B., P.F.S.

(Experimental Assistant Silviculturist, F.R.I., Dehra Dun.)

Introduction

The collection of seeds is one of those essential things that are in the category of inescapable items for a forest officer. If you do not want seeds yourself someone else wants them. At any rate, therefore, the job has got to be done. When the provincial silviculturist writes to a divisional forest officer to arrange for the supply of seed, the order is in due course entrusted to the range that is likely to have trees of the species concerned. But actually it is in nobody's interest to stop routine work to attend to it or in other words to regard the new order as a part of the routine. The enthusiastic officer will probably collect the seed himself, but that is a rare occurrence, for in case of repeated orders within the course of a seeding season the first performance is hardly likely to be repeated. Usually the collection is done by the fire watcher or a labourer under the direction of the beat guard and is often done gratis. There is thus hardly any incentive in many cases really to make it an interesting item of work.

The regular personnel, as obtains in most government forests, should however continue to be employed, because centralised supervision of seed collection is difficult. To improve matters, therefore, the collectors should be paid a price inclusive of an honorarium for the care taken and the supervision exercised. The usual practice is not to pay the forest guard anything. A vast improvement will result if adequate payment is made to the forest guard responsible for the collection.

The rules for the collection of seed are not many, but strict adherence to them is necessary to step up the quality of our artificial regeneration work.

Organisation

The selection of suitable mother trees or groups of mother trees is very essential and should be done as a part of routine work by a gazetted officer when on tour. For a group a rather open stocking of trees is desirable. These trees should be healthy trees of good form. The selected trees should be freed of competition and given plenty of light on the lines of a free thinning. Misshapen and branchy individuals of the same species should also be removed from the surround, to avoid, as far as possible, pollination from any but good trees.

List of these selected trees can then be compiled in the divisional office and copies supplied to the provincial silviculturist for record in his office for future reference.

Method of collection

A careful watch should be kept of the progress of ripening in the seeding season.

Generally, seed should be collected off the trees immediately natural seed-fall commences. Care should, however, be exercised to prevent injury to the trees. Fallen seed is apt to include a large proportion of immature and insect attacked seed.

The ground should preferably be swept clean at the commencement and only seed that falls or is shaken down, thereafter, should be collected.

Collection of seed can be done most cheaply and conveniently from fellings of the year, if these are done when the seed is ripe.

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SUITABLE SPECIES FOR DRY AND DESERT AREAS

By R. L. Badhwar
(*Minor-Forest-Products Officer, Forest Research Institute, Dehra Dun*)
In consultation with
Dr. A. L. Griffith
(*Central Silviculturist, Forest Research Institute, Dehra Dun*)

No list of plants possibly suitable for this kind of work at present exists, We have, therefore, compiled a list of plants (trees, bushes, herbs, shrubs and grasses) both indigenous and exotic which may possibly be useful in the afforestation of dry areas. Aganist each species is indicated the special type of work in which it might prove useful. Important uses of the plant and localities where it has been successfully used are indicated in the last column (8) of the list.

The Minor-Forest-Product Officer would be grateful if readers would consider this list and improve it by alterations or additions that they can suggest in the light of their experience.

The following abbreviations have been used.—**B**=*Bush* : **H** =*Herb* : **S** =*Shrub* : **T** = *Tree.*

Serial No.	Name	Possibly suitable for				Habit	Important uses and remarks
		Sand-binder	Arid areas	Irrigated plantations	Canal plantations		
1	2	3	4	5	6	7	8
1	*Acacia arabica* (Lam.) Willd. ..	..	..	X	X	T	Commercial gum acacia; bark and pod important tanning materials ; leaves and pods as fodder ; timber good for agricultural implements ; fuel.
2	*A. auriculaeformis* A. Cunn. *ex* Benth.	X	X	..	X	T	Fuel ; a north-Australian plant.
3	*A. caffra* Willd.	..	X	..	..	T	An African plant ; good for agricultural implements and fuel.
4	*A. catechu* (Linn.) Willd. ..	..	..	X	X	T	Gum ; cutch and catechu ; *kheersal* a medicinal product ; timber ; fuel ; fodder.
5	*A. confusa* Merrill	..	X	..	..	T	A Philippine plant ; good for agricultural implements and fuel.
6	*A. cyanophylla* Lindl.	X	X	..	..	S or T	Fuel ; a west-Australian plant which has done well on sandy soils in Cyprus.
7	*A. cyclops* A. Cunn. *ex* G. Don ..	X	X	..	..	S	Fuel ; very successful in S. Africa for afforesting shifting sands.
8	*A. eburnea* Willd.	X	X	..	..	T	Timber for agricultural implements ; fuel.

9	*A. farnesiana* (Linn.) Willd. ..	..	..	X	X	S or T	Flowers for essential oil; gum; timber for agricultural implements; fuel. The plant is supposed to be obnoxious to rats and snakes and is accordingly planted as a protection against the injury caused by these animals burrowing in the embankments.
10	*A. giraffae* Willd.	..	X	..	..	T	An African plant; good for agricultural implements and fuel.
11	*A. greggii* A. Gray	..	X	..	..	T	A Mexican plant; good for agricultural implements and fuel.
12	*A. jacquemontii* Benth.	X	X	..	..	S	Gum; fodder; fuel.
13	*A. karroo* Hayne	..	X	..	..	T	An African plant; good for agricultural implements and fuel.
14	*A. leucophloea* Willd.	..	..	X	X	T	Gum; timber; fuel; fodder.
15	*A. modesta* Wall.	..	X	..	X	T	Fodder; fuel.
16	*A. planifrons* W. and A. ..	..	..	X	X	T	Agricultural implements; fuel.
17	*A. robusta* Burch.	..	X	..	..	T	An African plant; good for agricultural implements and fuel.
18	*A. salicina* Lindl.	..	X	..	..	T	An African plant; good for agricultural implements and fuel.
19	*A. saligna* Wendl.	X	X	..	..	S or T	Fuel; a west-Australian plant which proved very successful in S. Africa for afforesting shifting sands.
20	*A. senegal* Willd.	X	X	..	X	T	Gum arabic; fodder; fuel.
21	*A. sundra* DC.	X	..	..	X	T	Gum; excellent hard timber for ship-building, posts and agricultural implements; fuel; fodder.
22	*Agave americana* Linn.	X	X	..	..	S	Fibre.
23	*A. sisalana* Perrine *ex* Engelm. ..	X	X	..	..	S	Excellent fibre; source of aliginates (substitute agars).
24	*Ailanthus altissima* (Mill.) Swingle (*A. glandulosa* Desf.)	X	X	..	..	T	Much reared in Europe for sericulture.
25	*Albizzia lebbeck* (Linn.) Benth. (*A. lebbek*)	..	X	X	X	T	Timber useful for various purposes and as match-wood; fuel; fodder.
26	*Alhagi camelorum* Fisch. (*A. maurorum* Baker) ..	X	X	..	..	S	Camel fodder.
27	*Anacardium occidentale* Linn. ..	X	..	..	..	T	Kernel of fruit valuable article of commerce (cashew nut).
28	*Anogeissus latifolia* Wall. ..	..	..	..	X	T	Gum; timber for agricultural implements; fuel; fodder.
29	*A. pendula* Edgew.	..	X	..	..	T	Toughest timber known, excellent for tool handles; fuel; fodder.
30	*Astragalus gummifer* Labill. ..	..	X	..	..	S	Commercial gum tragacanth; a plant of western Asia and south-eastern Europe; commercial supply mainly comes from Persia and Syria.
31	*Atriplex canescens* James ..	..	X	..	..	..	An American plant.
32	*A. nummularia* Lindl.	X	X	..	..	B	One of the tallest and most fattening and wholesome of Australian pastoral salt-bushes; excellent fodder for cattle and sheep.
33	*A. vesicarium* Heward	X	X	..	..	B	Said to be the most fattening and most relished of all the pastoral salt-bushes of Australia, holding out in utmost extremes of drought, and not scorched even by hot winds. Disseminates itself easily.
34	*Azadirachta indica* A. Juss. ..	..	X	..	X	T	Good tree for local medicinal use; timber; fuel; fodder for sheep and goats.
35	*Balanites roxburghii* Planch. ..	..	X	..	..	S or T	Fodder; fuel; fruit useful detergent for silk.

*Paper read at the 6th Silvicultural Conference, Dehra Dun (1945), on item 6—Afforestation of dry and desert areas.

Serial No.	Name	Possibly suitable for: Sand-Binder	Arid areas	Irrigated plan-tations	Canal planta-tions	Habit	Important uses and remarks
1	2	3	4	5	6	7	8
36	*Boswellia serrata* Roxb.	..	X	..	X	T	Gum-oleoresin ; timber ; fuel.
37	*Butea monosperma* (lam.) Kuntze	X	X	..	X	T	Flowers as dye ; gum ; useful in rearing lac insect ; fodder ; timber ; fuel.
38	*Calligonum polygonoides* Linn. ..	X	X	..	..	S	Common shrub in the Bikaner desert ; useful fuel ; flowers edible ; shoots used as fodder ; preventer of sand-drifts.
	(*B. frondosa* Koen. *ex* Roxb.)						
39	*Calotropis gigantea* (Linn.) Dryand. ..	X	X	..	..	S	Floss of moderate importance ; excellent fuel for preparing smoked fish.
40	*C. procera* (Linn.) Dryand. ..	X	X	..	..	S	Floss of moderate importance.
41	*Canavalia obtusifolia* DC. ..	X	X	..	..	Climber	Useful binder of loose sand.
42	*Capparis aphylla* Roth	X	X	..	..	S or T	Fruit used locally in pickles ; fuel.
43	*C. spinosa* Linn.	X	X	..	..	S	Fruit used locally in pickles ; fodder ; fuel.
44	*Cassia auriculata* Linn.	..	X	..	..	S	Bark excellent tanning material ; green manure.
45	*C. obtusa* Roxb.	..	X	..	..	S	Suitable for hills ; leaves purgative.
46	*C. siamea* Lam.	..	..	X	X	T	Useful timber ; fuel ; fodder.
47	*Casuarina equisetifolia* Linn. ..	X	..	..	..	T	Important fuel wood of S. India.
48	*C. muricata* Roxb.	X	..	..	..	T	Considered by some as a most important agent in the reclamation of waste sandy tracts. Stated to be a most hardy plant which will grow down to the high-water mark, and even amongst loose sand. It is also stated to act under certain conditions as a fructifier of the soil. A Malayan plant, considered by some to be synonymous with *C. equisetifolia*.
49	*Ceratonia siliqua* Linn.	..	X	..	X	T	Source of carob gum ; pods contain sugar and are a good fodder ; prefers rocky dry soil. The plant is very prolific in producing pods. Dry pods contain 50% of sugar and can be eaten as candy. Native of Syria, being cultivated in the Mediterranean region and America.
50	*Chloroxylon swietenia* DC. ..	..	X	..	X	T	Timber ; fuel.
51	*Citrullus colocynthis* Schrad. ..	X	X	..	..	H	Fruit of great medicinal importance. This, together with *Ipomoea biloba*, has been successfully cultivated to prevent sand-drifts near Surat and Karachi.
52	*Clerodendrum inerme* (Linn.) Gaertn. (*Clerodendron inerme*)	X	X	..	..	S	Drought-resisting plant ; good for hedges and for covering bare areas ; quick growing.

53	*Cocos coronata* Mart. (*Syagrus coronata* Mart.)	X	X	X	X	T	A very hardy Brazilian palm and resistant to drought; said to grow in places where few, if any, other plants can live; fails to adapt itself only in marshy soils or in situations permanently moist with stagnant water. Wax on leaves very important cheap substitute for Carnauba wax for shoe polishes and for making carbon paper. A palm yields ½ to 1 kilo annually. Fruit food for man and animal. Kernels of nuts yield 57–62% of an oil closely resembling coconut oil in taste and colour. Leaves for making hats, sacking, mats, ropes, as well as for feeding cattle. The palm apparently has vast possibilities.
54	*Commiphora mukul* (Hook. *f.*) Engl. (*Balsamodendron mukul* Hook *f.*)	X	X	..	..	T	Yields commercial gum-resin known as *gugal* or Indian Bdellum; fuel.
55	*C. myrrha* (Nees) Engl.	X	X	..	..	S or T	Yields commercial gum-resin called myrrh. A native of Abyssinia, Somaliland and Arabia.
56	*Cordia dichotoma* Forst. *f.* (*C. obliqua* Willd.; *C. myxa* C. B. Clarke *non* Linn.)	..	X	..	..	T	Fruit edible; timber; fuel; fodder.
57	*Dalbergia sissoo* Roxb.	..	..	X	X	T	Very important timber; fuel; fodder.
58	*Dodonaea viscosa* (Linn.) Jacq. ..	X	X	..	..	S or T	Hedges; fuel.
59	*Eucalyptus citriodora* Hook. ..	..	..	X	X	T	Essential oil; fuel.
60	*Eucalyptus* sp.	X	X	..	..	T	It would be well worth while to consider carefully the many *eucalypti* of the arid areas of Australia.
61	*Euphorbia neriifolia* Linn. ..	..	X	..	..	S or T	Latex used in local medicine. Useful as a hedge.
62	*E. royleana* Boiss.	..	X	..	..	S or T	Latex used in local medicine. Useful as a hedge.
63	*Feronia elephantum* Corr. ..	X	..	..	..	T	Fruit edible; gum; fodder; fuel.
64	*Ferula* sp.	X	X	..	..	H	Some species yield gum-resin known as asafoetida. High-level plants.
65	*Gymnosporia montana* Benth. ..	..	X	..	..	S or T	Wood durable; leaves used as fodder; useful as a hedge plant.
66	*Haloxylon ammodendron* Bunge ..	X	X	..	..	S or T	Prevents sand-drifts; performs most useful service in fixing the sand-dunes. One of the most useful species of Baluchistan. Excellent fuel. Yields a green dye.
67	*Heliotropium eichwaldi* Steud. ..	X	X	..	..	H	Valuable for fixing sand.
68	*Hydrophylax maritima* Linn. *f.* ..	X	..	..	..	H	A sand-binder.
69	*Indigofera paucifolia* Delile ..	..	X	..	..	S	Fodder; green manure.
70	*Indigofera* sp.	X	X	..	..	S	Sand-biders; fodders.
71	*Ipomoea biloba* Forsk.	X	X	..	..	H	Very useful twiner for binding loose sand and to stop sand-drifts. See remarks under *Citrullus colocynthis.*
72	*I. cernua* Hassler	..	X	..	..	S	A Brazilian plant; useful as a hedge.
73	*Jatropha curcas* Linn.	X	X	..	..	S or T	Seed medicinal; useful hedge.
74	*J. glandulifera* Roxb.	X	X	..	..	S or T	Sand-binder: useful hedge.
75	*Launaea pinnatifida* Cass. ..	X	..	..	..	H	One of the most important sand-binding plants on the coasts.
76	*Lawsonia inermis* Linn. (*L. alba* Lam.)	..	X	X	..	S	Yields the well-known henna dye; flowers used in perfumery.
77	*Maclura aurantiaca* Nutt. ..	..	X	..	..	T	An American plant; useful as a hedge.
78	*Melia azedarach* Linn.	..	..	..	X	T	Ornamental; timber; fuel; fodder.

Serial No.	Name	Possibly suitable for: Sand-binder	Arid areas	Irrigated plantations	Canal plantations	Habit	Important uses and remarks
1	2	3	4	5	6	7	8
79	*Morus* sp.	..	..	X	X	T	Good timber for sports goods; leaves fodder and important in sericulture; fuel; twigs for baskets.
80	*Olea cuspidata* Wall. (*O. ferruginea* Royle)	..	X	..	..	T	Wood for agricultural implements; excellent fuel; fruit edible; seed oleaginous. Suitable for hills.
81	*Opuntia dillenii* Haw. (spineless variety)	X	..	..	..	S	Fodder.
82	*Orthanthera viminea* Wight ..	..	X	..	..	S	Common shrub in arid areas.
83	*Othonnopsis intermedia* Boiss. ..	X	X	..	..	S	Prevents sand-drifts.
84	*Pandanus tectorius* Soland. (*P. odoratissimus* Roxb.) ..	X	..	..	..	T	Yields excellent essential oil; leaves for matting and basket-making; particularly useful when desired to raise sand-drifts in large heaps.
85	*Parkinsonia aculeata* Linn. ..	..	X	..	..	S or T	Growth rapid; useful as a hedge plant and as fodder; ornamental plant.
86	*Peganum harmala* Linn. ..	X	X	..	..	B	Useful as a sand-binder; seed commonly used as a disinfectant fumigant.
87	*Phœnix* sp.	X	X	..	..	T	Fruit; toddy; sugar; basket and mat-making from leaves; useful when desired to raise sand-drifts in large heaps.
88	*Pithecellobium dulce* Benth. (*Pithecolobium dulce*) ..	..	X	..	..	T	Avenue tree and a hedge plant; fodder; fuel.
89	*Poinciana alata* Linn.	X	X	..	..	T	Ornamental; branches and leaves used as a manure; wood useful for combs, matches, churns. Planted in Madras to protect the embankments from erosion.
90	*Pongamia pinnata* (Linn.) Merr. (*P. glabra* Vent.) ..	..	X	..	..	T	Seed oil; fodder; timber; fuel.
91	*Populus euphratica* Olivier ..	X	X	..	X	T	Matchwood; fodder; fuel.
92	*Prosopis cinerascens* A. Gray ..	..	X	..	..	S	An American plant; drought-resistant. This is probably *P. strombocarpa* as erroneously known in the Punjab.
93	*P. glandulosa* Torr.	X	X	..	X	T	Gum mesquite; pods edible; fodder; fuel. Recommended for planting shifting sands in dry localities.
94	*P. juliflora* (Sw.) DC.	X	X	..	X	T	Fodder; pods an important stock feed; gum mesquite; fuel. The tree grows very rapidly; is drought-resistant and can utilize arid, barren ground where few other plants would grow. According to some it is synonymous with *P. chilensis* (Molina) Stuntz.
95	*P. nigra* Hieron	..	X	..	..	T	An American plant; drought-resistant.
96	*P. pubescens* Benth.	..	X	..	..	T	An American plant; drought-resistant.
97	*P. spicigera* Linn.	X	X	..	..	T	Fuel; fodder.
98	*Pupalia orbiculata* Wight ..	X	..	..	..	H with a woody rootstock	Good sand-binder.

99	*Pycnocycla glauca* Lindl.	X	X	..	..	H	A perennial; sand-binder.
100	*Rhus lancea* Linn. *f.*	..	X	..	..	S	An African plant; useful as a hedge.
101	*Ricinus communis* Linn.	..	X	..	..	B or T	Very important oil; seedcake as a fertilizer; fodder; fuel.
102	*Salix tetrasperma* Roxb.	..	..	X	X	T	Matchwood: pollards for baskets.
103	*Salsola foetida* Del.	X	X	..	..	S	Good for saline soils. Used for making *sajji*, impure form of carbonate of soda.
104	*Salvadora oleoides* Decne.	X	X	..	..	T	Fruit eaten; fodder; timber for agricultural implements; fuel.
105	*S. persica* Linn.	X	X	..	..	T	Fruit eaten; fodder; timber for agricultural implements; fuel.
106	*Sophora griffithii* Stocks	X	X	..	..	S	Sand-binder.
107	*Suaeda fruticosa* Forsk.	X	X	..	..	S	Good for saline soils; camel fodder; used for making *sajji*.
108	*S. nudiflora* Moq.	X	..	..	..	S	Source of *sajji*.
109	*Sterculia urens* Roxb.	..	..	..	X	T	Commercial gum karaya; light timber.
110	*Tamarix* sp.	X	X	..	X	S or T	Fuel.
111	*Tecoma undulata* G. Don	X	X	..	..	T	Planted for ornamental purposes. Easily raised from seed and cuttings and coppices well. Wood for agricultural implements; leaves as fodder.
112	*Vitex negundo* Linn.	..	X	..	..	S	Most useful for afforestating torrent beds. The roots, leaves and fruits used in indigenous medicine. Shoots useful for basket-making. Useful as a hedge plant.
113	*Withania coagulans* Dun.	X	X	..	..	S	Fruit used as a vegetable rennet.
114	*Zizyphus jujuba* (Linn.) Lam.	X	X	..	..	S or T	Fruit eaten; timber; fuel; fodder.
115	*Z. nummularia* W. & A.	X	X	..	..	S or B	Fruit eaten; fodder.
	INDIAN GRASSES						
116	*Agrostis alba* Linn.	X	..	..	..	..	Valuable pasture grass for sandy seashore.
117	*Andropogon annulatus* Forsk.	X	X	..	..	..	Excellent fodder grass. Most useful sand-binder.
118	*A. foveolatus* Del.	X	..	..	..	..	Fodder grass.
119	*A. laniger* Desf.	X	X	..	..	..	Tufted grass with aromatic roots. Cattle fond of it when tender.
120	*A. pumilus* Roxb.	..	X	..	..	..	Annual Indian grass; good for fodder and hay. Flourishes in dry or semi-dry tracts.
121	*Aristida adscensionis* Linn.	..	X	..	..	..	Common on sandy ground; sub-gregarious on poor, shallow, dry, in fertile soils. A low-statured grass with little foliage andpoor feeding value.
122	*A. cyanantha* Steud.	..	X	..	..	..	A tufted bushy grass, typically of dry, arid and stony places. Not a good fodder.
123	*A. depressa* Retz.	X	X	..	..	..	Nourishing pasture grass.
124	*A. hystrix* Linn. *f.*	..	X	..	..	..	A perennial xerophytic sporadic grass of stony and rocky places. Fodder when young.
125	*A. plumosa* Linn.	X	X	..	..	..	Good fodder grass in western Tibet and western Himalayas. Important grass of Persia. Sahara desert and N. Africa.
126	*A. setacea* Retz.	X	X	..	..	..	Stems used for making screens (*tatties*) and brooms; not good fodder.
127	*Arundinella setosa* Trin.	..	X	..	..	..	A perennial grass chiefly on rocky ground and dry hills. Used for brooms. Not relished by cattle.

Serial No.	Name	Possibly suitable for: Sand-Binder	Arid areas	Irrigated plan-tations	Canal planta-tions	Habit	Important uses and remarks
1	2	3	4	5	6	7	8
128	*Bothriochloa pertusa* A. Camus ..	..	X	..	..	..	A perennial grass of dry areas. Good fodder for grazing and stacking. Stands long periods of drought.
129	*Cenchrus catharticus* Del. ..	X	X	..	..	..	Good fodder.
130	*C. ciliaris* Linn.	X	X	..	..	..	Good fodder when young. For silage the grass should be cut in the flowering or in the seed stage. Not killed by drought once it is established.
131	*C. montanus* Nees	X	X	..	..	..	One of the most nutritious of grasses; makes good hay.
132	*Chloris barbata* Sw.	X	X	..	..	..	A perennial tufted grass of sandy soil. Stands drought well. Fodder.
133	*Chrysopogon montanus* Trin. (*Andropogon monticolla* Schult.) ..	X	X	..	..	..	A perennial grass of dry, sandy or stony soils with little capacity for holding water. Valuable fodder grass.
134	*Cymbopogon martinii* Wats. ..	X	X	X	..	..	Important essential oil (Rosha-grass oil, Palmarosa oil, not good fodder.
135	*C. parkeri* Stapf	X	X	..	..	..	Useful for covering dry, sunny, eroded slopes between 3,000 to 4,000 ft. Not good fodder.
136	*Cynodon dactylon* Pers.	X	..	..	..	..	Important pioneer grass. Quickly covers bare surface. Important for soil erosion, because of creeping surface-rooting habit. Excellent lawn and fodder grass.
137	*Dactyloctenium aegyptium* Beauv. (*Eleusine aegyptiaca* Pers.) ..	X	X	..	..	..	Valuable fodder grass; grain edible. Common on sandy soil near the seashore where it lasts throughout the winter.
138	*Desmostachya bipinnata* Stapf (*Eragrostis cynosuroides* Beauv.) ..	X	X	..	..	..	Good thatching grass; good desert fodder; makes good ropes and mats.
139	*Dichanthium caricosum* A. Camus (*Andropogon caricosus* Hook. *f.*) ..	X	X	..	..	..	A perennial of dry and sandy habits. Good fodder.
140	*Eleusine flagellifera* Nees ..	X	X	..	..	..	Good fodder.
141	*E. scindica* Duthie	X	X	..	..	..	Good fodder.
142	*Elionurus hirsutus* Munro ..	X	X	..	..	..	Good fodder; makes excellent hay. Root fibre used as weaver brushes. Characteristic plant of Rajputana desert tract.
143	*Eragrostis tremula* Hochst. ..	..	X	..	..	..	Annual grass common in light sandy soil in the plains, especially on poorly cultivated ground. Considered very good fodder grass in Ajmer.

144	*Eulalia quadrinervis* O. Kuntze (*Pollinia quadrinervis* Hack.) ..	..	X	..	..	..	Perennial grass not destroyed by fire or drought.
145	*Eulaliopsis binata* (Retz.) Hubbard (*Ischaemum angustifolium* Hack.)	..	X	..	..	..	Good for paper-making, ropes, mats and baskets; moderately good fodder.
146	*Imperata cylindrica* (Linn.) P. Beauv. (*I. arundinacea* Cyrill)	X	X	..	..	..	Perennial with deep-rooted rhizomes. Stands drought well. Important pioneer grass in land reclamation. Useful for thatching and paper-making.
147	*Melanocenchris royleana* Nees ..	X	..	..	..	..	Pasture grass.
148	*Panicum antidotale* Retz. ..	X	X	..	..	..	Opinions regarding its fodder value differ. Used in indigenous medicine.
149	*P. miliaceum* Linn.	X	X	..	..	..	Yields excellent green fodder and is largely grown for the purpose. Useful sand-binder.
150	*P. repens* Linn.	X	X	..	..	..	Useful sand-binder and a good fodder grass.
151	*P. turgidum* Forsk.	X	..	..	..	..	A desert or sand-dune grass; fodder.
152	*Perotis indica* (Linn.) O. Kuntze (*P. latifolia* Ait.) ..	X	..	..	..	..	Fodder grass.
153	*Phacelurus speciosus* (Steud.) Hubbard (*Rottboellia speciosa* Hack.)	..	X	..	..	..	Perennial tufted grass. Often the only one found in the sandy soil in the dry valleys.
154	*Saccharum ciliare* Anders. ..	X	X	..	..	..	Thatching; fibre for matting, basket and screens; fodder when quite young.
155	*S. munja* Roxb.	X	X	..	..	..	Can grow on the driest of soils. Yields commercial *munj* fibre used for making baskets, mats, cordage and ropes: leaves for thatching and paper-making. Found of considerable use in Jaipur as sand-binder. Not a fodder grass.
156	*Saccharum* sp.	X	X	..	..	..	Some species, such as *S. spontaneum* Linn., possess considerable value on account of their capacity for fixing, shifting and unstable soil.
157	*Spinifex squarrosus* Linn. ..	X	..	..	..	..	Excellent sand-binder near the coast. The dried shoots and roots may be used as fuel.
158	*Sporobolus orientalis* Kunth ..	..	X	..	..	..	Grass of saline tracts of northern India, Sind, Madras, often constituting the entire vegetation.
159	*S. virginicus* Kunth	X	X	..	..	..	A seashore plant; useful for seashore reclamation.
160	*Stipa pennata* Linn.	X	X	..	..	..	Useful sand-binder.
161	*Trachys mucronata* Pers. ..	X	..	..	..	..	Useful for seashore reclamation.
	FOREIGN GRASSES						
162	*Agropyron junceum* Beauv. ..	X	..	..	..	..	Perennial grass of sandy seashore of Europe. Good for seashore reclamation.
163	*A. pungens* R. & S.	X	..	..	..	..	Perennial grass of sandy seashore of Europe. Good for seashore reclamation.
164	*A. pycnanthum* Gren. & Godr. ..	X	..	..	..	..	Perennial grass of sandy seashore of Europe. Good for seashore reclamation.
165	*Agrostis maritima* Lam. ..	X	..	..	..	..	A stoloniferous maritime grass of Europe and North America. Suitable for seashore reclamation.

Serial No.	Name	Possibly suitable for				Habit	Important uses and remarks
		Sand-binder	Arid areas	Irrigated plantations	Canal plantations		
1	2	3	4	5	6	7	8
166	*Ammophilla (Psamma) arundinacea* Host [*A. (psamma) arenaria* (Linn.) Link].	X	..	..	..	..	Common on maritime sands on all the coasts of Europe and North America, and has been extensively planted elsewhere as a sand-binder. After some years a light soil forms, in which other plants take root. It has proved a great success in South Africa.
167	*Aristida berbicollis* Trin. & Rupr. ..	X	..	..	..	..	A deep-rooted xerophytic grass, very important in South Africa in the early stages of grassland plant succession.
168	*A. bipartita* Trin. & Rupr. ..	X	..	..	..	..	A deep-rooted xerophytic grass, very important in South Africa in the early stage of grassland plant succession.
169	*Aristida brevifolia* Steud. ..	X	X	..	..	..	A suffrutescent, deep-rooted, very xerophytic grass of Africa covering wide areas of desert; a most important pioneer grass for desert. Not good fodder.
170	*A. congesta* R. & S.	..	X	..	..	..	A deep-rooted xerophytic grass, important in S. Africa in the early stages of grassland plant succession.
171	*A. junciformis* Trin. & Rupr. ..	..	X	..	..	..	A deep-rooted xerophytic grass, important in S. Africa in the early stages of grassland plant succession.
172	*A. pungens* Desf.	X	X	..	..	..	Important grass of Sahara desert and N. Africa.
173	*Calamovilfa longifolia* Scribn. ..	X	..	..	..	..	Sand-binding plant of Western Great Plains (America) and dune regions.
174	*Cenchrus pauciflorus* Benth. ..	X	..	..	..	..	Common sand-binder of America.
175	*Crossotropis grandiglumi* Stapf	..	X	..	..	..	One of the most important of the drought-resisting perennials; a common pioneer on stony hillsides all over the eastern side of S. Africa and Arabia.
176	*Ehrharta brevifolia* Schrad. ..	X	..	..	..	..	A sand-binding grass on the coast and dunes of S. Africa.
177	*E. gigantea* Thunb.	X	X	..	..	..	Useful pasture grass for sandy areas. Proved very successful in S. Africa.

178	*Elymus arenarius* Linn. ..	X	..	..	..	..	A widespread European species with long, creeping rhizome. Well known as a sand-binder and is often planted for this purpose in various parts of the world. Grain edible.
179	*Eragrostis cyperoides* Beauv. ..	X	..	..	..	..	Sand-binding grass; important pioneer in early stages of plant succession in S. African grass-fields.
180	*E. glabrata* Nees	X	..	..	..	..	Sand-binding grass; important pioneer in early stages of plant succession in S. African grass-fields.
181	*E. spinosa* Trin.	X	X	..	..	..	A spiny desert grass, covering vast areas of sandy soil in the dry areas of the Western Karroo (Africa).
182	*Festuca littoralis* Labill. ..	X	..	..	..	..	Important sand-dune grass in Australia.
183	*Fingerhuthia africana* Lehm. ..	..	X	..	..	..	A tufted, xerophytic, deep-rooted grass of S. Africa.
184	*Odyssea mucronata* Stapf ..	X	..	..	..	..	A creeping perennial sand-binder of Arabia, Somaliland and Socotra.
185	*Pennisetum clandestinum* Hochst. ..	X	X	..	..	..	A creeping perennial of E. Africa; important for checking soil erosion. Cultivated as fodder and as a lawn grass.
186	*Polypogon maritimus* Willd. ..	X	..	..	..	..	A Mediterranean species; introduced elsewhere. Good for seashore reclamation.
187	*Redfieldia flexuosa* Vasey ..	X	..	..	..	..	American grass growing gregariously on drifting sand which its rhizomes help to bind.
188	*Schmidtia bulbosa* Stapf ..	X	..	..	..	..	One of the most important xerophytic grasses in the sand-veld of S. Africa.
189	*Spartina maritima* (Curt.) Fernald..	X	..	..	..	..	Commonest halophytic grass of temperate zone; introduced successfully in S. Africa. Important in the reclamation of seashore marshes.
190	*S. townsendii* H. & J. Groves ..	X	..	..	..	..	A most important agent in seashore reclamation work; an European species introduced into New Zealand and utilized for this purpose. Good as fodder and for thatching and paper-making.
191	*Spinifex hirsutus* Labill. ..	X	..	..	..	..	Common Australian and New Zealand stoloniferous grass. Very important as a sand-binder.
192	*Uniola paniculata* Linn. ..	X	..	..	..	..	Common on the coastal dunes of America; excellent sand-binder with creeping rhizomes.
193	*Zoysia japonica* Steud... ..	X	..	..	..	..	A Japanese grass introduced into America as a good lawn grass. Good for checking soil erosion.

Note.—It has not been possible to mention the economic uses of all the foreign grasses.

NOTE ON INSECTS IN PROSOPIS SEEDS

By J.C.M. Gardner

(*Forest Entomologist, Forest Research Institute, Dehra Dun*)

1. The insects concerned are mainly Bruchidae (*Pachymerus gonagra*), a few microlepidopetra, a Silvanid and *Tribolium castaneum* being of minor importance judged by emergencies in material tested.

2. Preliminary experiments were made to determine (*a*) efficiency of paradichlorbenzene and of naphthelene in killing attack already present and (*b*) effect of each agent on germination.

3. A summary of (*b*) has been published by Griffith, 1945, *Indian Forester*, 71: 251.

4. Efficiency of treatment

Method.—Infected pods of *Prosopis* of various origins were divided into two comparable lots of 1 lb. 11 oz, each. Each lot was confined in air-tight glass containers of 7,000 c.c. and treated with 1 gram of paradichlorbenzene and naphthalene respectively, and left closed for 2 months 14th November 1944 to 15th January, 1945. The two lots were then removed to breeding cages to note emergence of adults (different origins were not tested separately.)

A third lot, of 5 oz. of mixed pods was not treated and kept as control.

Results. The results up to 24th November, 1945 are as follows:

Treatment	*Total emergences*	*Emergences per pound of pods*
Paradichlorbenzene	0	0
Naphthalene	1182	700
Control	302	966

Summary.—Treatment with paradichlorbenzene in a closed vessel at 1 gm. per 7,000 c.c. capacity for 2 months killed all insects. (Effect of treatment on germination stated by Griffith to be little or none).

Treatment with naphthalene under similar conditions had little or no effect on the viability of the insects present; the rate of emergence from treated pods was only slightly lower than from untreated material (Effect on germination stated by Griffith to be little or none).

More than one generation succeeded in both naphthalene and control lots between January and November 1945.

Remarks

Treatment of infected pods with paradichlorbenzene at the rate of 1 gram per 7,000 c.c. capacity of the air-tight container for two months effectively killed all insects. It must not be assumed however that re-infection will be prevented in seed after treatment since the chemical (normally in crystals) is volatile. Cotton (1941, Insect pests of stored grain) states that this chemical is excellent for seed protection provided that air-tight containers are used; also that since 1,000 cubic feet of space holds only 0.5 lb. of the vapour a larger dosage may be used only to cover absorption and leakage. It is possible that a weaker dosage than that used in the F.R.I. experiment might be efficacious. But note difference between protection and disinfestation.

Note.—In the article in the August 1945 issue quoted above, where a "normal" dose is referred to it means the 1 gm. per litre dose used in the experiment as compared with the heavy overdose used later. The "normal" dose does not refer to any "standard" dose developed in work done elsewhere.—*Hon. Ed.*

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* 0.5 lb. to 1,000 cu. ft. ≡ .01 gm. per litre (approx.)

FOREST MANAGEMENT OF CANAL STRIPS AND AVENUES IN THE PUNJAB*

By K. Sultan Mohammad Khan

(*Extra Assistant Conservator of Forests, Punjab*)

The narrow strips of land on both sides of canals and distributaries are primarily intended for

(*a*) dumping ground for the excavated earth,

(*b*) making silting tanks for the strengthening of banks,

(*c*) as reserves of new earth for widening the banks,

(*d*) possible widening of the channel to increase the capacity for water.

The question of using all lands available in plains for providing fuel and timber is now very much in the lime light and in this respect canal lands, after the forest department plantations, are of primary importance. They can very well be utilised for growing trees suited to each condition of climate and soil.

Apart from the supply of timber and firewood for public and departmental use, the provision of (*a*) material for bushing and stacking for the protection of banks against erosion, desiccation and channel training, (*b*) shade for the comfort of travellers and protection of roads and (*c*) grass and fuel to the surrounding populace, are some of the direct advantages of canal bank plantations.

Extent of canal plantation.—The area suitable for forest growth on either side of the main lines and branches of the canals total some 38,000 acres according to the report on canal planations.

The predominant species on all these canals are *sissoo* (*Dalbergia sissoo*) and *babul* (*Acacia arabica*) averaging about 30 per cent. of the tree growth, taking the canals as a whole. The tree crops wherever they occur are generally very open, though a number of dense *sissoo* pole plantations occur here and there.

Taking the canals as a whole it is doubtful whether the fully stocked area exceed 20—25 per cent. of the total area suitable for plantation. The remaining areas are either blank or stocked with valueless growth. The scope for improvement is therefore enormous. Probably 60 per cent. of *babul* now existing could be replaced by *sissoo* which is very much more valuable and less liable to damage by lopping.

Climate and soil conditions.—The canals traverse almost the whole of the Punjab plains which are characterised by extremes of temperature. The tract may be divided into two rainfall zones.

(*i*) The arid zone with annual rainfall from 15 inches down to 5 inches and (*ii*) the moist zone with more than 15 inches and up to 30 inches.

The greater part of the tract lies in the arid zone. The following types of soil are met with.

(*a*) *Sandy or clayey loams.*—These represent the fertile soil.

(*b*) *Kallar.* Patches of saline soil are found sporadically in clayey soil mixed with *kankar* and *rappar* which tend to form a hard pan a little below ground level and prevent the downward development of roots of trees. Such soils often become water-logged in rains and are thus unfit to bear trees.

(*c*) *Pure sand.* This soil is unfertile.

(*d*) *Water-logged areas.*

The soil of the canal strips is moist and, except where the ground is above the water level of the canal or is saline or water-logged, is quite suitable for the growth of *sissoo* trees of good quality. On high spoil banks good *babul* forest can generally be grown.

The moisture content of the soil due to seepage from the canals, is sufficient, with some exceptions, to support the trees once they are established without further irrigation. This is a valuable consideration as the trees will require nothing but thinning and protection from youth to maturity.

Protection.—The most important consideration in the selection of channels for afforestation is the possibility of affording protection to the young crops. The future of canal plantations depends mainly upon the protection afforded to them against damage of browsing and lopping. The young plants if browsed once in the first year suffer a serious set back in growth and if browsed again have little chance

***Paper presented at the 6th Silvicultural Conference, Dehra Dun (1945) on item 6. The Afforestation of Dry and Desert Areas.**

of future development. It is thus absolutely necessary to exclude grazing and so rigorous care should be exercised to protect the young crops during the first 3 years. Ordinarily canal bank strip less than 30 ft. wide should be ignored. (*Note by the central silviculturist.* This is contrary to U.P. practice where they consider it worthwhile in places where their forest is only 1 tree wide.)

Remoteness is unlikely to prove a limiting factor because the demand for timber and fuel has so increased with increasing population and better standard of living even in villages. The consideration of transport difficulties of the canal wood to the distant big towns and cities will not affect its profitable disposal, as soon as its supply is offered to the public. These conditions are unlikely to change for many years to come.

Choice of species.—On commanded areas with sandy or clayey loam *sissoo* is most suitable. It can also be raised economically in uncommanded reaches, not very high above the water level of the canal and having an average annual rainfall of about 25 inches, by hand watering in the hot weather of the first year. *Babul* may be grown on uncommanded areas with an annual rainfall below 15 inches. It flourishes best on new spoils and can grow on soils with a degree of salinity.

In sandy tracts with an annual rainfall down to 8 inches mesquite (*Prosopis glandulosa*) is being tried. For water-logged and low-lying areas willows, *Eucalyptus* spp., *arjun* (*Terminalia arjuna*) and *jaman* (*Eugenia jambolana*) are successful.

Method of growing sissoo.—The best method of growing *sissoo* is by means of stumps from one or two years old nursery grown plants; provided the new shoots can be protected for a year or two.

Direct sowings involve great skill, labour and time, are most expensive, need more water and succeed in good soil only. They are quite unsuited to canal bank strips where the ground is very undulating and the water difficult to control.

The method of raising *sissoo* crops where irrigation water can be laid on closely follows the practice of irrigated plantations and need not be described at length here. Stumps are planted as early in the growing season as possible, from March onwards. The whole success depends upon an adequate and even distribution of water, and as the ground is often very irregular, the layout and grading of the trench system requires most skill and attention, particularly as it has to be done by eye, followed by one or more trial irrigations.

High uncommanded areas with average annual rainfall 30 inches or more.—*Sissoo* avenues and plantations are successfully raised on high uncommanded areas by planting stumps in pits and watering them by hand. The plants if completely protected from browsing damage need no watering after the second year; where conditions are eminently favourable *i.e.* high water table, good protection, and adequate rainfall, watering in the first year only may be sufficient.

Method of planting.—To reduce the expense of hand watering circular pits of the shape of a shallow trough (figure 1) $1\frac{1}{2}$ ft. diam. 12 inches deep are dug by the end of February. In the avenue lines these pits are 10 ft. apart and in the plantation area 20 ft. apart in the lines and 6 ft. in rows. Closer spacing in the rows is provided in order to produce better timber trees.

FIG. I

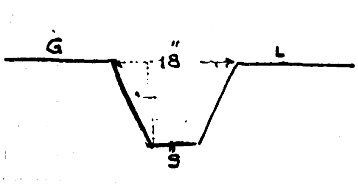
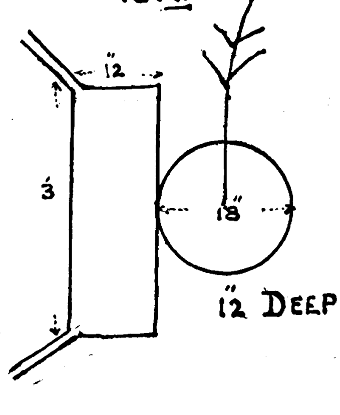


FIG. II



In the month of March stumps are planted in the centre of the pits; immediate watering after planting must not be neglected. The dug up soil helps early development of shoots by retaining moisture and affording better aeration.

With the regular break of monsoon watering is discountinued and labour is employed on digging trenches of dimensions $3' \times 1' \times 1'$ on the upper slope adjacent to the pits, with catch water arms as shown in figure II. In this way the maximum amount of rain water is made available for the plants. One *beldar* should suffice to hand water 300 plants a day.

In the first year the stumps require thorough watering every 4th day before sprouting, then every 6th or 7th day subsequently, no watering in the rains, thrice in September and October, none in November to January, once a week in February and March, and twice a month in April to July. Watering may not be required later on if plants are healthy and have grown 10 to 15 ft. high. In fact no rigid rules for watering can be laid down as it is the capacity of the individual soils to retain moisture and the amount of rainfall which decides the question.

High uncommanded areas with annual rainfall less than 30 *inches*.—Very successful *sissoo* regeneration can be obtained in the form of root suckers by severing the roots of the parent tree in the following way:

Trenches 1 ft. wide and 1 ft. deep are dug in circles round the stump of the felled tree at 10 ft. distances from the stump, up to a maximum distance of 40 ft. The severing of the roots induces a crop of suckers in the trenches, and with favourable soil and moisture conditions complete restocking may be effected in this way.

Where root sucker production is not effective, *sissoo* stumps are planted in pits, as described for uncommanded areas with 30 inches or more of rainfall, and hand watering done.

Babul sowing.—Where the soil is poor or too high above the seepage level from the canal to support good *sissoo*, trenches 4 ft. long 1 ft. wide 1 ft. deep are dug 10 ft. apart in lines and rows, and *babul* sown on the berms and lightly covered with earth just as the rains break. On unstable and sloping soils *babul* seed is sown in circular pits about $1\frac{1}{2}$ ft. diam. and 6 inches to 9 inches deep 10 ft. apart and 10 ft. in lines. Some seeds may be sown before the monsoon.

Necessity for protection.—*Babul* ranks next to *sissoo* in economic importance. The wood yields excellent firewood and charcoal. The timber is of great value for helves and country cart wheels while the bark is very much valued by the tanning trade. Being prized by goat herds for fodder and by zamindars for fencing it is subject to merciless lopping throughout its life and so requires great protection.

Treatment of areas overgrown with kana.—There are miles of commanded and uncommanded reaches infested with *kana* (*Saccharum munja*) to such an extent that tree growth cannot compete. Its annual sales bring in only a nominal return.

The scanty tree crop which sometimes exists is seriously damaged by the annual burning practised by the villagers to induce a fresh *kana* crop with the result that no young trees of any species are found in these areas.

The high cost of eradicating *kana* prohibits this operation in commanded areas where no valuable crop of trees can be grown but it is proposed that the commanded areas be leased out for cultivation and then taken up for planting *sissoo*.

Treatment of low-lying and water-logged ground—Mounds 2 ft. in diam. at the top and high enough to be 12 inches above the seepage water are preparped after stubbing out bulrushes or other rank growth of *dub* grass. Cuttings of willows or plants or *Eucalyptus* are then planted on these mounds. Willow cuttings should be at least of one year old branch wood, $\frac{1}{2}$ inch to 1 inch thick and about 2 ft. long. They are planted with a slight slant. These plants should be kept quite free from the shade of tall weeds, if any. The best species of *Eucalyptus* for water-logged areas are *E. melanophloia*, *E. microtheca*, *E. rudis*, *E. rostrata* and *E. teriticornis*.

Treatment of sandy soil.—In sandy soil *sissoo* stumps having $1\frac{1}{2}$ ft. to 2 ft. root portion are fairly successful. *Babul* and *ber* (*Zizyphus jujuba*) can also be grown but require very great protection.

Fencing.—

(*a*) Bush fences are ineffective.

(*b*) Barbed wire is effective generally but is not always obtainable. It has the advantage that it can be used over and over again.

(*c*) *Pise de terre* walling is useful in combination with a ditch 3 ft. wide $\times 1\frac{1}{2}$ ft. deep on the

outside about $1\frac{1}{2}$ ft. from the wall where rainfall is low but is very expensive.

(*d*) Boundary ditches 5 ft. top width, 2ft. bottom width, depth 4 ft., are effective to some extent, but mischievous villagers break down the sides and drive their cattle into the plantations.

Lopping.—The prevention of illicit lopping is difficult without statutory provisions of the Indian forest act. Departmental lopping for bushing and stacking should in no case be done for more than half the height of tree nor should the trees be lopped for the supply of firewood to the local officials who should be supplied by orderly fellings.

Tending operations.—Weeding. After 2 or 3 irrigations weeds come up quickly especially in case of planting ot stumps late in the rainy season when the new shoots cannot compete, and weeding is essential, as often as may be indicated.

Cleanings.—In areas bearing a profuse crop of root suckers and coppice it is necessary to cut out the unnecessary shoots in order to promote the growth of promising future stumps. It is best to carry out this operation in December and January following the felling of the area. The shoots retained should be evenly spaced so as to permit sufficient growing space.

Pruning.—Pruning of the branches should be carried out only in avenue line trees when they have attained 15 ft. height and are not less than 2 years old or are interfering with the free traffic on the road. Pruning should not be done up to more than one half the height of the trees.

Rotations.—Avenue lines will be grown on a long rotation, probably 50 years. *Sissoo* strip plantations will be managed as coppice with standards on rotations of 18 and 54 years respectively, for firewood and timber. *Babul* will be grown on a rotation of 25-30 years as this is the minimum required to produce trees of the most economic value.

Rejuvenation of poor sissoo in avenues.—Plants which have suffered a set back in their growth due to defective planting or irrigation, or repeated browsing and have become bushy or half dry, are cut back to the ground in December or January. The defect of inadequate irrigation must be removed and the new shoots, which are bound to be vigorous, must be completely protected against browsing damage. The plants regain their normal condition in a short period if properly attended to.

COMMEMORATIVE TREE PLANTING

By C. Padmanab, B.Sc. (For.) Edin.

(*Forest Adviser, Bundelkhand Agency, Nowgong, C.I.*)

Now that the war has happily ended in complete victory to the Allies, public minded ladies and gentlemen will get busy collecting funds for erecting suitable memorials to commemorate this great victory and to honour those who fell fighting for the freedom of the world. The following is my suggestion for the most appropriate way of keeping the memory of the brave ever green.

It has been a long standing practice among the Americans to honour both the living and the dead in a charming fashion by planting trees to commemorate them. In recent years England has followed suit. For example, the Silver Jubilee plantings in 1935 and those carried out with the due ceremony in Windsor Park to commemorate the coronation year. In a country like India, it is surprising to find this custom completely forgotteen. This is a country in which we still worship trees like *peepul* (*Ficus spp. bel* (*Aegle marmelos*), *ashok* (*Saraca indica*), *arjan* (*Terminalia arjuna,*) *deodar* (*Cedrus deodaru*) and a host of others. These are worshipped not for the sake of the spirits that live in them but for their economic and aesthetic value.

The biological definition of a tree is known to everybody. Aesthetically, every tree is beautiful because it expresses a rhythm resulting from certain organic impulses ; the impulse to grow and reach towards the sunshine, the impulse to maintain its equilbrium and the necessity of resisting the movements of the wind. It has not tried to be beautiful. It has only wanted to live. Yet the result is something perfectly harmonious and immensely satisfying.

To plant a tree is to launch a life. It is a commemorative act in terms of something vital,

something that will grow in vivid beauty long after the corresponding stone or moulded metal has succumbed to ignominious decay. In the first place statuary memorial plaques and paintings are definitely expensive. Secondly they are often as not deplorably inartistic and out of keeping with their surroundings to the secret mortification of subscribers and sorrowing relatives. None of these things can truly be said of a tree, particularly a well chosen species which is well looked after.

No other country in this world can compete with India in her wealth of tree species, beautiful for their foliage and blossom. Here are some of them:

The *gul mohur* (*Poinciana regia*), *jaman* (*Eugenia janbolana*), *Sterculia*, *Albizzia*. *Dalbergia*, *ashok* (*Saraca indica*), *Jacaranda*, *Ficua*, (spp.) etc., etc.

This is a land where the "burden of the heat of the day" is not a phrase but an actual fact. Those in the dusty heat and glare of our roads can never have enough of such natural blessings. Many are the cities filled with useless and unsightly statues and sepulchral monuments even though no one has yet heard of citizens sheltering in a statue's "graceful shade."

I request every one interested in commemorative activities to ponder over this. Sympathetic forest officers exist everywhere who will be only too glad to take the opportunity given to them to help and instruct the memorial committees in erecting evergreen monuments of their design.

EXTRACTS

SHELTERBELT INFLUENCES *

II. THE VALUE OF SHELTERBELTS IN HOUSE-HEATING†

By C. G. Bates.

(Principal Silviculturist, Lake States Forest Experiment Station, St. Paul, Minn., U.S.A.)

A good belt of trees protecting the farm home was estimated by farm owners in eastern South Dakota to reduce the fuel bill about 25 per cent. according to a survey conducted by the shelterbelt administrative force in 1935. That this is well within the limits of a belt giving substantial protection only from northerly winds, is shown by the experimental data here presented and analysed; while protection from both north and west winds may increase this substantially, and all-around protection in the centre of a grove or forest might effect a saving of 40 per cent. The experimental data have been adjusted to actual heating conditions of the typical farm home, and calculations made for wind and temperature conditions which prevail at four different latitudes in the plains region. These facts should discourage the removal or too severe thinning of farmstead groves in the present emergency, with a view to effecting savings in coal. Total fuel consumed may be much greater if the protective belt is weakened, and only dead wood could profitably be employed to replace coal.

*The first article in this series, " General description of Studies made", appeared on pages 88—92 of the *Journal for Forestry* for February 1945; and was reproduced on pages 231—325 of the *Indian Forester* for September 1945.

†It is regretted that the present part of this interesting series could not be reproduced here *in extensio*. We have therefore endeavoured to put in the author's introductory abstract of the article followed by its summation in which he has very lucidly condensed the entire argument. We hope the above representation does not detract seriously from the value of the article. For a fuller study however of the value of shelterbelts in house heating we refer readers to pages 176—196 of the *Journal of Forestry* for March 1945.—Ed.

Summation

As has been implied, besides showing fuel-use rates for seven temperature levels, the results are put in the most usable form in a table. The assumption is that reductions of wind by wind-breaks are more likely to be of the general order of 35 per cent. than any other, and that if they do not vary too widely from this standard, or say within the limits of 25 to 45 per cent., it will be sufficiently accurate to assume that the reduction in fuel use (the complement of the ratio given) will be proportionate to that computed for the 35 per cent. wind reduction, at the proper initial wind and temperature level. If there is any doubt of this, it will be quite simple to calculate the fuel-use reduction ratio for any initial velocity and percentage of wind reduction. Straight-line interpolations between even miles per hour cannot create any serious error, although in preparing the table giving fuel-use rates, interpolations on the curve have been made.

All of this permits ready calculation of the percentage of fuel that can be saved, without having to think in terms more technical than the present amount of fuel used per season, or its cost. However, it should not be inferred from this that sound predictions can be made without (1) at least a qualitative knowledge of the present heat losses of the house and whether they are high or low because of the character of wall construction (and insulation) or because of losses around windows and doors and through other cracks such as those which all too often occur at eaves and foundations; and (2) a fairly exact knowledge of the wind velocities to which the house is exposed,* and the temperature of the heating season, although some error in the latter item will have no important effect.

Integration of results to Seasonal Basis.—It has been emphasised in the article that fuel reduction rates for ratios are specific for certain winds and temperatures and combinations thereof, and the ratios shown in the table of fuel-use rates clearly illustrate this. On one day, with a 20 m.p.h. wind and zero temperature there might be saved 35 per cent. of the fuel, while with the same 35 per cent. reduction in wind, for a temperature of 30° F. and a wind of 10 m.p.h. the saving would be only 19.6 per cent. of the fuel which otherwise would have been consumed on such a day. Moreover, the basic fuel use would have been slightly more than one-fourth as much (1,619 against 6,257 heat units per hour) on the milder of the two days. While, then, the table may be used for direct estimation of saving for short periods representing specific weather conditions, it is evident that only by adding together the amounts of heat that would be used in all of the different kinds of days that occur in a heating season, and each of these in its normal proportion, can it be ascertained what the fuel saving is in terms of the winter's fuel bill.

No attempt has been made to do this except for certain combinations of conditions which are fairly typical of the plains region as a whole. The integrated results to which reference will be made will not be at all applicable if the correlation between temperature and wind velocity which occurs in the plains does not exist in the local climate. For example, a locality in which the winds of higher velocity occur in the coldest months would reverse the plains correlation, and hence would produce a different integrated result for the heating season.

Primarily to determine the frequency of occurrence of winds of different velocities, but also to bring out any existing correlation between wind velocity and temperature, wind records from the airport at Huron, South Dakota, for the heating seasons falling within the calendar years 1940, 1941 and 1942, a total of 838 days, have been classified to the nearest mile (24-hour averages, only, used) and the days on which each occurred classified as to temperature in 10 degree groups† The mean velocity for all days was 13.038 m.p.h., the extreme velocities 37.0 and 3.5 m.p.h., and the mean temperature for the heating season is 35.70 degrees but during these years averaged about 2 degrees above this normal. Velocities are expressed as percentages of this average, as it is believed

*It is very unfortunate in this connection that, although all first-order weather bureau stations have for years obtained wind velocity and direction records, these are not comparable for different stations because of variations in exposure, nor can they be said to represent the wind velocities of the open country nearby. It is to be hoped that, as a result of present observations of flying fields, it may be possible to build up a framework of data to show actual velocities at various elevations above open ground. Even these better readings, however, are not to be taken as representing velocities at the stated elevations above ground: anemometers are, as before, generally 12 feet above the building roof, and the effect of the building cannot be ignored.

† The published data necessary for these computations have been furnished through the courtesy of Mr. B. R. Laskowski, section director of the weather bureau at Huron.

the same relative scale may be applied where the mean velocity is either higher or lower.

Since the writer knows of no such data being published, and it may be helpful in other relations, wind frequencies are shown in a separate table. Only at the extremes where the groups are not well filled out have exact averages been computed.

While these calculations are for the heating season of 279 days in this particular case, it may be assumed that the relative frequencies would not be changed appreciably were the heating season shorter, or were the entire year employed, although the average velocity for such season might be higher or lower.

As to correlation between wind and temperature, this is mainly due to a marked rise in wind with increase of temperature in March and April, with only a slight wind recession in May, this being typical of the plains as a whole. This seasonal relation is not obscured by a contrary trend in the fall.

Thus, with adjustments necessary to put temperatures on a normal basis, and to reduce the Huron airport velocities to these which are likely to prevail at 12 feet above ground, or approximately at the middle of a 2-storey house. the 838 heating-season days have been divided into for periods showing the following characteristics:

No. of days	*Ave. tem., °F.*	*Ave. vel. 12 ft. above ground m.p.h.*
122	1·8	9.76
267	24	10.45
244	42	11.09
137	61.25	11.34
68	70.60 (requiring no fuel use).	

This implies that, to obtain an integrated heat-use ratio, the amounts of heat-use with and without a given wind reduction should be worked out for the four temperature levels, and within these, for each of the eight velocity levels shown in the table of wind frequencies. Having performed these calculations for each temperature, the four will be combined in the proportions shown by the number of days for each.

The integrated result in this case, for wind reduction throughout of 35 per cent. is a ratio of .7791. This ratio is found, by the table of fuel-use rates, and at the mean heating-season temperature of 36 °F. to apply at a wind velocity of 11·80 m.p.h. whereas the mean 12 ft. velocity is 10.795 m.p.h.

In short, then, due to the far greater importance in the season's total fuel use of the minority of days having appreciably more than average wind velocity, we are justified in assuming that to read the fuel saving somewhat directly from the table of fuel-use rates, one mile per hour may be added to the true mean velocity which is applicable in the circumstances. Withal, the effect of temperature on the ratios is small, yet it is obvious that in a climate in which the highest wind velocities were associated with the lowest temperatures, the significance of high-wind periods will be still further augmented.

A separate calculation has been made from the assembled data to show what effect will result from the tendency with nearly all windbreaks to give an increasing percentage wind reduction with higher velocities.* If it be assumed that 35 per cent. reduction of wind is obtained at average velocity, and that this increases or decreases 0.5 per cent with each m.p.h., the effect of this added factor is to change the average ratio of .7791 only to .7757. However, as this ratio applies at a velocity of 12.05 m.p.h., it more firmly establishes the fact that the full m.p.h. may be added to the mean, where long periods and a great variety of winds and temperatures are involved.

Degree of wind reduction to be expected from Tree belts

Tree belts placed about farm buildings may give much or little protection, and in the northern plains may complicate or simplify the problem of snow drifting about buildings, according to their placement composition and density, and, of course, their height. While even the protection near the ground line given by a thick hedge may be helpful, obviously the trees should be taller than the house to be protected to obtain the kind of results which the test houses have brought out. Very close

*A windbreak of a given type does not reduce the wind by a given number of miles per hour, but more nearly by a given percentage at all times. Actually, this percentage, at most positions, increases as the wind velocity increases, so that, for example, if a 5 m.p.h. wind were decreased 20 per cent., or 1 m.p.h., a 15 m.p.h. wind might be decreased 25 per cent., or 3.75 m.p.h. Since calculations here show that this change may be disregarded, if we determine the *percentage* by which the wind is reduced at any medium velocity, this percentage may be applied to the true mean velocity for a season, with insignificant error.

to the windward side of a belt, air currents produced by strong winds are being "shot" upward, but they quickly turn down again, and over the top of a wide grove should be thought of as horizontal, with a tendency to dip as soon as the edge is reached. Height is not so important therefore, if the house may be placed quite closely in the lee of a narrow belt. But again, this may be an area of considerable snow settling.

Of all the items which effect the *degree of wind reduction*, it is safe to say that none is so important as the *area* which may be devoted to trees. While two rows of trees do not have double the effectiveness of one, and the value added is less with each row, it is only through mass effects that very complete stilling of the air can be obtained. It has been pointed out that the 70 per cent. reduction in wind caused by the circular barrier used in this experiment could hardly be duplicated for winds from all directions, or for the average anywhere except in an opening more or less in the center of an extensive grove or forest; and that if this is to be an opening of an acre, so that the yard is not encumbered by trees at all, the grove must be, let us say, 70 feet high. Even in such an opening one would naturally seek the north side to obtain best protection for a house, and in this opening there would be little or no problem of drifting snow. With such protection, the data of the table giving fuel-use rates show that where the mean heating-season temperature is 20°F. a saving of 42.1 per cent. in fuel might be made (using the 12 m.p.h. line), or for 400 temperature, 39.9 per cent., these values being roughly 1.8 times the saving to be had with wind reduction of only 35 per cent.

With many farmsteads, it is feasible to have a substantial belt only on one side of the house, or at most two. Almost invariably the north side will be first choice. If, possibly, the house is too close to a road on that side, or to other buildings, the west will be second choice in the northern plains, but of considerably less importance or value farther south. In the northern plains not only are north and northwest winds somewhat the more persistent through the heating season, and likely to show the most extreme velocities, but also temperatures are 4 to 5 degrees lower when the winds are in that quarter than when southerly. Since snow drifts is mainly from the north and north-westerly direction, there is added reason for having the belt on the north, but only if it is of sufficient width to form a snow trap may best advantage be taken of a position close to it.* With narrower belts, both snow movement and actual wind protection at the higher velocities dictate that the distance shall be more nearly five times than twice the height of the trees.

Such being the facts, it is desirable to observe just how good is "one-way protection". Unfortunately, there is available but one set of readings, on a hardwood belt, covering a sufficiently long period in the winter (with the trees leafless) to give representation to winds of all directions which must be taken into account. Even these observations are deficient, in that there are no comparative readings *except at an elevation 16 inches above ground*. These, however, show less effect of ground friction than usual, as a good , somewhat wavy blanket of snow covered the ground during most of the period. This east-west belt at Huron, S. Dak., was studied during February 1937, and is believed to be fairly typical of the better farmstead protection commonly obtained from the hardwoods which were almost exclusively used in early plantings. It was 200 feet wide, with the cottonwoods, which occupied the north half, 70 feet high. Green ash trees about 40 feet high, in the south half, kept the belt as a whole from being as open, below, as it would otherwise have been. All of the trees were old, however, and there was scant under growth.

For the entire period of 27 days measurements on this field average wind equivalent to 12.03 m.p.h. at an elevation of 12 ft., while the "ground control" at 16 inches above the snow level averaged 9.62 m.p.h. According to Huron Weather Bureau records, all northerly winds accounted for 55.8 per cent. of them ileage, while the normal for winter is only 44.3 per cent. from northerly quarters. Average temperature was 16°F. Under these circumstances, a point 3-H, or 210 ft., south of the edge of the belt showed the lowest average velocity near the ground, 60.2 per. cent of that at the controls. At 2-H it was 62.2 per cent.

*Mechanically, there is less difference between the different sides of belts, in protection given, than might be supposed, if season-long velocities be considered. The north side of a compact belt (this is quite untrue if the wind can sweep under) may give, say, four-fifths as much protection as the south side. The very conditions which make possible such wind reduction at 2 heights north, however, cause this to be the worst possibie place for snow drifts.

As with many other belts of such open character, and with slat barriers, higher velocity was shown at the leeward edge of the belt—75.9 per cent in this case. Based on the showing at 3-H, assuming the percentage reduction in wind to be the same at 12 feet as at 16 inches, but reading the table of fuel-use rates at 12.5 m.p.h, (for a partially generalized situation) it is found a 40-per cent reduction at 160 temperature should reduce fuel use to 2,017 B.t.u. from 2,783, or by 766 B.t.u. per hour, or 27.5 per cent.

For a total of 150 hours it is possible to segregate unmixed north-west winds covered mostly by short intervals between observations. For this time the average 12-foot velocity is 12.35 m.p.h., that near the ground 10.64 m.p.h., and at the "low" point, 3-H south of the trees, 5.01 m.p.h. or 47.1 per cent of the control. Temperatures with such winds averaged about 13°F. Again using 12.5 m.p.h. as the base, and 5.9 for the reduced velocity, the heat quantities involved become 2,990 for full wind, and 1,933 for the reduced wind, a saving of 1,057 B.t.u. per hour, or 35.4 per cent.

For two consecutive days wind at the control, for 12-foot elevation, averaged 18.93 m.p.h. from the north-west, the ground wind 15.24 m.p.h., and that at 3-H south of the belt 6.66 m.p.h., or 43.7 per cent of the control, while temperature was about 15°F. Assuming that the 12-foot velocity with protection was 8.25 m.p.h., the heat values involved are 4,189 B.t.u. for full wind and 2,233 for reduced wind, a reduction of 1,956 B.t.u. and 46·7 per cent.

These latter values, of course, represent short periods. The purpose in discussing them in detail is, in part, to show the method to be employed in use of the tabular data, but more particularly to emphasize the point that the greater survivings of fuel, as expressed by percentages, come at the times when the fuel use is high.

The question remains as to whether the measurements made on this belt may be considered as representative of the heating season as a whole with application to the climatic conditions where made or to others. In attempting to answer this question the fact that the south side of this belt, during the measurements received more than normal protection from north winds may be pitted against the fact that the reduction in wind velocity, in this case as in all similar cases undoubtedly would have been greater at the level of 12 feet, than at the level of only 16 inches above the snow blanket. This applies usually out to a distance of 7-H to 8-H, and is particularly true of stations close to the belt or barrier. We may take it as an assured fact, whenever the structure of the barrier is such as to permit marked currents of wind to "blow under", and to show higher ground velocity immediately to leeward than at points somewhat further away. This characteristic has been noted with the slat barriers which are of the same "density" from top to bottom, and is even more likely to be noted with old trees which offer little resistance near the ground.

Although data for this belt were not taken, a setup on an ash grove, 40 feet high, with measurements made in September, 1935, after the leaves had dried and were partly fallen, gives a clear indication of the nature of the phenomenon. Velocities above ground were not, in this case, taken at a control-station (except at 16 inches and 16 feet), but rather at 5-foot intervals on "towers" erected at a distance of 2-H both on the windward and leeward sides. However, the windward station velocities may be adjusted to control-station values, at least up to a height of 16 feet, by very simple relations.

With or without this adjustment, it is found that at all wind velocities above 10 m.p.h., the leeward station shows the lowest ratio to windward velocities at the elevation of 15 feet, while with a wind of about 5.4 m.p.h. the 25 ft. level showed the greatest reduction. Selecting a NNW wind of 11.73 m.p.h. as nearest to the means that are of interest, with the adjustments, these ratios read .544 at 16 inches, 447 at 5 feet above ground, .396 at 10 feet, and .378 at 15 feet. From this level they increase approximately to .600 at the level of the tree tops. Thus, interpolating for 12 feet in elevation, we have a ratio of .389 to compare with the "ground" ratio of .544 in this case. Certainly we may count on a fifth greater reduction of wind 12 feet above ground than where the observations were habitually made for close-in leeward positions. The same effect occurs in lesser degree when the same station becomes a windward one. For this grove there was, at 2-H on the south side, a general wind reduction percentage at 12-foot elevation at least one-eighth greater than that indicated by the anemometers at 16 inches elevation. It is our judgment—going back to the grove measured under winter conditions—that the same effect would prevail there to the extent

of about one-tenth, and that this would just about counterbalance the lesser frequency of north winds in a full, normal winter.

A fully integrated, normal "benefit" from this cottonwood and ash grove would, therefore, be obtained by assuming that the normal wind for Huron, which is about 10.8 m.p.h. at 12-foot elevation, would apply, and that the reduction at this elevation (probably more certainly obtained at 2-H than at 3-H) would be 40 per cent. as first stated, and that the mean heating season temperature would be 36° F. As already pointed out, the integrated result is that which applies at a velocity of 11.8 m.p.h.; the ratio is .779, the fuel saving is 22.1 per cent. for 35 per cent. reduction in wind, and when extended one-seventh for the 40 per cent. reduction becomes 25.2 per cent.

It is surprising to note that no data are available giving a sound basis for a substantially higher estimate of fuel saving than was obtained in the case just cited, for single belt or what may be termed "one-way protection from north winds." The only conclusions that can logically be drawn from the data studied in this connection are that slightly better results are obtainable with a more compact type of windbreak, *if* the position is the very best possible; but that actually the open, screen-like type of belt is far more effective than its appearance indicates.

Particularly effective hardwood belts in the plains region have shown summer wind reduction on the leeward side, with direction essentially normal to the axis, to be as great as 70 per cent. within a limited area. Such reductions are obtained only where there is good support by underplanted or flanking trees, so that relatively little wind can move *under* the main body of trees. This is the type of protection one would expect also wtih conifers, and they should have the advantage of giving the same degree of protection in winter as in summer. DenUyl* has given the results of a number of measurements on coniferous belts in Indiana. Using his data for "density class 3" and for wind of 15 m.p.h., in the open, his reduction figure of 73 per cent seems possibly applicable to the type of growth that is attainable in the plains. This applies at a distance of 2-H leeward, under the same limited conditions as to wind direction.

However, observations on barriers at Miller, S. Dak., over a period of about three months in the late winter of 1937-38, show that, when winds of all directions are considered, there may be expected at a point 2-H south of the barrier only about 65 per cent. (for safety, say 63 per cent) of the wind reduction that accrues when such point is definitely on the leeward side. It, therefore, follows that with the best or most compact type of windbreak the general reduction on the south side, for plains conditions, will not exceed 45 per cent. This, plainly, is no great gain over the cottonwood belt.

With respect to two-way protection, data for the barrier setup at Huron give the only available basis for estimating the value of a protected "corner". As has been stated, in the plains region protection from the north or west or, when possible from both directions, is commonly sought. The barrier position was in reality a west corner, not a north-west corner, and being in fact between two parallel barriers set to meet north-west winds, primarily, was also not entirely free of protection from the south or south-east. However, as the one-way protection at the centre of this barrier was affected similarly, we may compare the corner with the centre without further correction. Ordinarily, a point only 2-H from the barrier, and the same distance in from its end, will have, by comparison with the centre, much less protection. With similar protection on two sides, the end or "corner" position over a period of about 35 days, with better-than-average velocities, showed nearly half again as great a reduction in wind, The actual, averages were, at the centre of the barrier 33.1 per cent. reduction, and at 2-H from its end, with the supplemental protection on the south-west, 46.3 per cent. reduction. A station at the centre of the end or cross-barrier showed only 33 per cent. reduction, while at the southerly intersection (protection from south-east and south-west) the reduction was 39 per cent.

*If, then, it be taken that 40 per cent. reduc*tion represents a fair maximum for one-way protection, it is apparent that a house located in a west or north-west corner, protected by two similar belts, may well expect wind reduction of 55 per cent. This is just halfway between one-sided and all-around protection. Based on the normal heating season conditions for Huron, this implies fuel-use reduction of 33.0 per cent.

*DenUyl, Daniel, Zone of effective windbreak influence, *Jour. Forestry*, 34 : 689—95, 1936.

Value of Fuel Savings in different Latitudes

In discussions to this point the findings at Holdredge have been applied only to the combination of wind and temperature found at at Huron, S. Dak., solely because it was most feasible to combine all of the elements in the problem from data obtained in that vicinity.

It is evident from the table on fuel-use rates, since increasing wind velocity augments the value of wind reduction, while lower temperatures do the same in a less marked degree, that the value of a given amount of protection might either increase or decrease from north to south. It so happens, for the stations for which it is feasible to develop a reliable measure of prevailing wind velocities, for the elevation of 12 feet above ground and representative in all cases of extremely flat terrain, that there is a sufficiently great increase in wind velocities from north to south to compensate for the shorter and milder heating seasons to the south. As shown by the table on wind-reduction effects for different latitudes in the plains, there seems to be a strong probability that, if the same meridian were adhered to throughout, the percentage of fuel saving would prove to be slightly greater in Kansas than in North Dakota. This, of course, is on the assumed basis of 40 per cent. wind reduction throughout. If actualities were considered, there probably would be little or no difference in the average case, because it is considerably more difficult to develop tall and dense shelterbelts in the southern portion of the plains.

Of greater importance than the percentage of fuel saved, of course, is the actual amount for a season. To make clear the magnitude of seasonal amounts, there have been inserted in the table on wind-reduction effects for different latitudes the hourly rates (interpolations of the table on fuel-use rates) both with and without the indicated wind reduction. Multiplying the use per hour in the latter case by the number of days in the heating season gives relative values on total fuel use, found to be roughly 277M B. t. u. in Kansas against 450M B. t. u. on the edge of the very cold Red River Valley in North Dakota. While this is a ratio of about 6 to 10 the larger percentage which it is possible to save in Kansas makes the seasonal saving there worth about 0.67 times as much as in North Dakota. In this respect, the North Dakota and South Dakota stations give almost identical results, as do the Kansas and Nebraska stations. These calculations take no account of differences in heating by sunlight at various latitudes.

Obtaining wind Protection in the Plains

A reduction of even $15 to $20 annually in the fuel bill, together with the reduced labour of handling, and the greater comfort which may be attained through ability to heat different parts of a house more evenly in the windiest weather, justify not only giving considerable care to the placing of shelterbelts about farm homes,* but also devoting considerable space to them. Only by the latter may the *best* results be obtained.

Unfortunately, throughout the plains, protection from wind is inseparable from the problem of drifting snow, and it is for this reason that the planning of protection deserves great care, else the advantages may be largely balanced by the setting up of new difficulties in the way of shovelling paths, confining livestock to their stables, and making the movement of vehicles impossible. Even in the southern plains, where snow is much less a persistent impediment through the winter than in the north, the occasional snows are often accompanied by high winds, and create as great hazards and inconveniences as elsewhere. All that one can hope to do, by the best use of shelter, is to cause the snow to fall and remain in as even a layer as possible in the farmyard—when it is rarely of sufficient depth to cause great inconvenience—and to prevent the drifting in of snow from great open spaces that may surround it. The latter may be much the more serious item, as this vagrant snow stops only when it finds a sanctuary from wind. However, it rarely drops with the *first* tree it encounters and, if a belt be too narrow, may frequently be found well on the leeward side.

Since the circumstances which will dictate the best form and place for shelters are variable without limit, about all that we may hope to do is to list certain broad groups of possibilities, in order of preference. Plainly, under certain circumstances the least desirable plan or one slightly higher in the scale, is the only one that is at all feasible.

1. Location in centre of grove on forest of considerable extent. In an opening up to one acre in extent wind should be the lowest that

*The town or village dweller obtains a certain degree of protection through the aggregate effect of all buildings, but locally this protection may be very inadequate. Trees accomplish a great deal in " filling the gaps " between buildings through which tornadic streams of air may otherwise flow. See paragraph 5 on page 196.

will be encountered anywhere. House in north-west corner of opening will have maximum protection while receiving ample sunshine from south and east. There will be no drifting through of snow, but there may be a heavier fall than elsewhere when wind is from north or west, within, 2 or 3 rods of the trees, and this marginal space should be left. Completeness of protection depends, of course, on height of trees relative to that of house.

2. If the grove of trees is of small extent, say not over 1 to 3 acres, a notch cut out of the south-east corner will offer the best protection from north and west winds; and there is also some reduction when wind is from south to east and "banks" against the trees. There may occasionally be drifting of snow when falling, with easterly wind, but this is unlikely to be serious.

3. Creation of widest possible belt to north and west of buildings, or at least to north, with massed outbuilding giving protection on west. Unless width of belt is 4 rods or more, or density is maintained by encouraging all possible undergrowth, snow may occasionally drift through. This can be very largely eliminated by planting a second narrow belt or tall hedge after original trees begin to lose lower branches 3 to 4 rods outside of the main belt, forming between them what is commonly called a "snow-trap", for snow which may blow in from open fields. Divide this by cross hedges if length from east to west is over 100 ft. The snow trap area often makes an excellent garden tract.

4. Where space permits only a very narrow belt to north or both north and west of dwelling, drifting both during storms and later may be expected; and because of this the house must be set back far enough to make certain the drifts do not encroach on the doorstep. There is a tendency to feel that with only one or two rows of trees possible, evergreens must be used to obtain good protection. The danger in the plains is that some of the trees will prove short-lived; and as death causes gaps in the "solid" barrier, through which snow will be readily carried, the drifting problem may be as great as with deciduous trees. This, again, is likely to occur when the conifers lose their early bushy form. It is strongly recommended that row of conifers always be flanked by another row of thick growing hardwoods. Each row should have space enough so that the trees will retain their branches, and also may grow a little taller than trees which are crowded, because of having more ground to draw upon for moisture. In this way the slower growing conifers will not become overtopped and weakened.

5. For the yard already so developed that there is no room for a belt at the more desirable distance, and for hill-top sites where poor tree growth and the slope of the ground, make it next to impossible to obtain protection from trees several rods distant from the house, a "direct screen" of trees is probably the most practical means for obtaining moderate protection. This means placing the trees so close to the house preferably on the north and west sides—that they at least bear the brunt of the wind's pressure. Obviously this is a place where a compact mass of evergreens would be highly effective, while they will not be exposed to breakage as much as though they were standing alone.

In this case we do not attempt to avoid snow drifting, but so confine the scope of the trees that it will be little more than that cause by the house itself, and will consist principally of "streamer" drifts to leeward. Evidently the the drive, if any, would be in safest position to the north of such trees. Piling of snow against the house will do no harm where there are no doors; but if it is an impediment near the ends of the L-shaped screen, for example, it can be avoided by keeping the lower branches trimmed off.

If the single row of trees close to north and west walls can be somewhat "supported" on the north-west corner, so as to form a wedge pointing into the strongest winds, the effectiveness will be greatly increased. In this case the outer trees, or point of the wedge, should be of less height than those near the wall, so that the wind is "lifted" as well as being diverted laterally. In short, design this wedge or point like the point of a plow or the pilot of a locomotive.

Addendum.

The mean 12-foot wind velocity at Huron, 10.8 m.p.h., which is used as the basis for several earlier calculations and appears in the table on wind reduction effects for different latitudes in the plains, has been found to be too low. It is believed that it represents the general latitudinal trends, however, better than the true local figure, and for this reason the calculations made on this basis have not been changed. Retention of the lower figure here tends to keep the implied benefits on a more conservative basis. The true velocity will be shown in the next article of this series.

—*Journal of Forestry*, Vol. 43, No. 3, March 1945.

TRENCH-MOUND METHOD OF AFFORESTATION

J. P. MASCARENHAS, B.Sc., DIPL. FT. (GERMANY)
Mysore Forest Service
and
SYLVESTER PAIS, B.A.
Coffee Planter, Chickmagalur, Mysore

Virgin forests are the gift of nature. They form the economic wealth of a country to a great extent. The most obvious things that one gets from the forests are timber and fuel which are useful to man for his domestic purposes. But they serve man in every walk of life, yet the percentage of population that pays attention to their preservation is very low. Exploitation of the growing stock to meet the daily needs of man must be well compensated by artificial regeneration and cultural operations. With the advance in civilazation and increase in population the demand on forest resources is daily on the increase with the result that nature is not able to replenish the requisite growing stock.

Bare tracts and need for afforestation

Scientific forestry has brought into play ways and means to combat the various causes that have laid bare many a rich forest tract. Years of experience in the field have taught the forester to imitate nature and adopt measures to afforest open tracts and blanks to a certain standard. Climatic conditions and nature of soil play to a great extent the most important role but they are so varied that even the best forester may sometimes get baffled when he does not obtain the anticipated results.

Localities with varied conditions of soil and rainfall naturally need different methods of cultural treatment and, so much so that no one method can be recommended to stock an open tract. Apart from natural disadvantages, there are other causes directly governed by men which need perhaps more attention. With an ever increasing demand for timber and fuel our aim, however, should be to see that at least one-third of the country should remain under forest well distributed for proper management to meet the growing requirements of the people.

An inspection of the bare hill slopes and the woodless lands all over the country will show that the main causes are the following: (1) scanty and scattered rainfall, (2) draught in summer for long periods, (3) indiscriminate goat browsing and grazing of cattle, (4) lopping of trees for fodder, (5) indiscriminate cutting of saplings and trees for fuel and agricultural implements and (6) frequent fires.

The direct and indirect advantages of forest growth in nature are not realized by many. The forests grown by nature have to be looked after and protected by man. Nature fails and retaliates if man interferes too much with her work.

Nature the best guide in species selection

The problem is how to restock these areas with suitable species and for this, nature itself is the best guide. This can be studied by the species growing in particular localities and other species which can stand similar conditions can well be introduced. Climatic conditions may not be uniform all over the tracts and this would mean a careful selection of the species to be introduced after experiment. Soil factors exercise a great control on account of the poor conditions of the soil and this can be solved by a judicious selection of the species which can best thrive in the locality. Lastly, the local demands should also be studied carefully while introducing the species in the area.

Afforestation of bare hill slopes

Afforestation of bare hill slopes is a problem which needs to be tackled first. The rain water causes soil erosion to a great extent. Only a very small fraction of it percolates into the soil and the bulk of it which runs on the surface is not made available to vegetative or tree growth in the area. The main objects to be achieved in any afforestation work are: (1) checking soil erosion on bare hill slopes, (2) increasing retention of the moisture content of the subsoil by arresting rain water, (3) helping accumulation of silt from the slopes and (4) growing fuel, fodder and economic species.

Afforestation work in Mysore

It has to be stated that certain methods of afforestation work introduced in the Mysore State since 1930 have given satisfactory results.

The State of Mysore occupies a position physically well-defined in the south of India. It is a table-land situated within a triangle where the Eastern and Western Ghat ranges converge into the group of the Nilgiri hills. It is enclosed by chains of mountains to the west, south and east, on whose shoulders, the plateau which consititutes the country rests. The country is everywhere undulating and broken up by lines of rocky hills or high mountains with deep *nallas* and ravines. The greater part of the province consists of *maidan* tracts or open country, though intermediate regions partake of the characteristics of both, *e.g.*, the transition from the *malnad* to *maidan*. The southern and western belts of the state are richly stocked with forest growth. The eastern and northern belts are poorly stocked with forest growth and give place to wide plains.

Two important methods of afforestation introduced both in the *maidan* and *malnad* tracts have proved successful and they may be enumerated here.

Trench and mound sowings

This method is best suited to steep hill-slopes which are bare of vegetation and are therefore continuously eroded by torrential rain. The main object to be attained in such localities is to retain the soil and moisture to aid plant growth. The system consists of preparing interrupted trenches about 30 ft. to 50 ft. long along the contours on the slopes as may be necessary, to catch and retain a large part of rain water and prevent loss of soil by run off. The space between rows of trenches and their lengths vary with the steepness of the slopes operated upon. The steeper the slope the shorter should be the trenches and closer the spacing. Trenches of 12 ft. in length at 12 ft. spacing will do well. As the slope eases down the lengths of the trenches, as also the distances between rows of trenches, increase. In a very easy gradient, trenches of 30 ft. to 50 ft. length at intervals of 20 ft. to 30 ft. would do very well. The depth of trenches should be about 2 ft. and the top width between 1½ ft. to 2 ft. The fundamental principle of laying out the trenches in level along the contours should be strictly observed, as otherwise the trench becomes a water channel instead of holding rain water. The lower side of the trench must be scraped thoroughly to a width of about 1½ ft. and the earth from the trench thrown into mounds of 6 in. to 9 in. depth. Trenches are to be dug and mounds prepared at least a week before sowing. This process keeps off the rodents to a great extent as otherwise they disturb the mounds and there is every likelihood of the seeds being eaten up. Better results are obtained by burning both the trenches and the mounds. Soon after the trenches are ready seeds are sown both on the mounds and in the trenches. The trench by arresting rain water tends to retain and increase the subsoil moisture for a longer period, thus helping the seedlings to establish themselves. This is usually done between the months of April and May after the onset of the first shower of rain. These experiments have been conducted successfully in many districts and sowings of *sandal* (*Santalum album*) and *seemethangedi* (*Cassia siamea*) seedlings have attained a height of 4 ft. in one growing season (*vide* plate 3.)

Patch sowings

Patches 4 ft. × 4 ft. are prepared by digging to a depth of 1 to 1½ ft. in the month of November, the earth being kept on a side. The average spacing of the patches is about 10 ft. to 12 ft. apart. In April of the following year, the well aerated and worked out soil is thoroughly burnt over with brushwood and leaves so as to get rid of roots, fungus and insects, etc. The burnt debris acts as a good manure too. The soil is then formed into raised beds of 3 ft. × 3 ft. A trench of about 6 ft. to 9 ft. wide is left all round the raised bed for the collection of rain water. The bed is now ready for sowing of seeds of suitable species in May of the year just before the onset of rains. With one or two showers of rains the seeds will have enough water for germination and before the close of the rains in November the seedlings will have established themselves. Beds of 3 ft. × 3 ft. are recommended to keep off grass and also for further operations.

The patches and trench-mounds must be covered with thorns so as to prevent damage by goats and cattle. During the months of August and September, the thinning of congested seedlings and the weeding of patches have to be attended to.

Time of sowing

The correct season for sowing of seeds depends on the localities and climatic conditions which must be accurately ascertained. Localities affected by south-west monsoons need earlier sowings. The usual season is between April and June after a heavy shower. There may be failures on account of long break. In some

Fig. 1. Trench mound sowings under *taungya* system, Bettahalli Kaval forest
Photo Venkat Rao

Fig. 2. Afforestation by *taungya* system, Nijagal forest
Photo Venkat Rao

cases the failure may be up to 50 per cent but these can be resown in the months of June and July and continued even till August. Best results have been obtained from sowings done in the month of May. Wherever early rains set in, sowings during the last week of April also have given good results.

Species to be selected

In the selection of species the first thing to be considered is the requirement of the people in surrounding areas and secondly, the climatic conditions of the area. After setting apart some grazing ground for cattle and goats, other areas may be stocked and provision made for introducing say, the following species:

1. Leaf fodder : *Acacia* (*leucophloea*), *Artocarpus integrifolia* (*Halasu*), *Melia Indica* (*Bevu*), *Pithecolobium saman* (rain tree), *Ficus Benghalensis* (*Alada Mara*), *Ficur Mysorensis* (*Goni mara*).

2. Yielding leaf manure : *Pongamia glabra* (*honge*).

3. Yielding fuel manures : *Cassia Siamea* (*Sime Thangadi*), *Dalbergia sissoo* (*Sissoo*), *Eugenia jambolana* (*Neralu*), *Hardwickia binata* (*Kemara*), *Eucalyptus citriodora*, *Butea frondosa* (*Mutuga*).

4. Economic species : *Anacardium occi- , dentale* (cashew), *Sapindus trifoliatus* (*antwala*), *Semicarpus anacardium* (marking nut), *Spondias mangifera* (*Amte*), *Feronia elephantum* (wood-apple), *Boswellia serrata* (*Sambrani*), *Terminalia chebula* (*alale*), *Psidium guava* (*sibe*), *Phyllanthus emblica* (*nelli*), *Anona squamosa* (*seethapal*), *Albizzia lebbek* (*Bage*), *Tamarindus indica* (tamarind), *Mangifera indica* (mango), *Acacia arabica* (*Jali*), *Schleichera trijuga* (*sugade*).

Other methods

Apart from these two important methods, a scheme closely related to the *Taungya* system of cultivation has also been started in the *maidan* tracts. This consists of selecting suitable areas (10 to 15 acres generally) bare of tree growth and allowing private individuals to plough the land and grow horse-gram, Bengal-gram and the like. Seedlings of *Casuarina* raised in nursery departmentally are supplied to individuals for planting 6 ft. apart, at the same time allowing them to sow seeds. These people are allowed to grow their crops for two to three years and are required to replace casualties, if any. When the plants grow sufficiently big, they are asked to discontinue their operations and to take up fresh areas. By this means, with the co-operation of the people in the villages, large areas can be stocked with fuel and other species. In the district of Bangalore, *Casuarina* plantations have been raised and multiplied with great success.

It has to be noted that a good deal of educative propaganda is necessary for the reconstruction of forests. The villagers should be made to understand the need and their co-operation secured. In any case, it can be confidently stated that afforestation schemes, particularly the trench-mound method, have met with a fair measure of success in Mysore.

—*Indian Farming*, Vol. VI, No. 3, March 1945.

FORESTERS AS TOPOGRAPHIC MAPPERS IN THE REDWOODS

C. K. LYMAN

(*Silviculturist, Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Mont*)

One of the war jobs taken over by the Forest Service was the topographic mapping of the coastal area of northern California. The rigid technical requirements, the giant redwoods, and the foggy weather combined to make an unusually tough assignment. How the major difficulties were overcome makes an interesting addition to the annals of the forestry profession.

Not long before Pearl Harbor the War Department inaugurated an extensive program of mapping strategic coastal areas in the United States. Topographic maps suitable for defensive combat operations were needed in a hurry for thousands of square miles. Since the mapping facilities of the Corps of Engineers were inadequate to complete even the portion most urgently needed with sufficient speed, assistance was requested from the U. S. Geological Survey, U. S. Coast and Geodetic Survey, Tennessee Valley Authority, Forest Service, and Soil Conservation Service. In addition, much work was contracted. This action was far more than a precautionary measure, but at this time full explanation of the reasons is a

matter for military men—not a civilian. It can be said, however, that anyone living on the fog-bound coast of northern California at the time the Japs were making their greatest strides welcomed well-planned defensive measures.

An area of approximately 1,611 square miles in the giant redwoods between Eureka, California, and the Oregon state line was included in the three areas assigned to the Forest Service. Mapping specifications called for a scale of 1 : 31,-680 with a 50-foot contour interval. The limits of error were established as one-half a contour interval vertically and one-fiftieth of an inch horizontally. These unusually high specifications together with the conditions of vegetation, topography, and climate made this a most difficult mapping project.

In the opinion of experienced topographic mappers, this area was one of the most difficult in the entire United States. Some stated that mapping in accordance with the prescribed specifications was practically an impossibility. Many were of the opinion that costs per square mile would be extremely and possibly unreasonably high. It was known that ordinary methods, either ground or air, would not be suitable.

A new adaptation of combined ground and aerial techniques was required. This new method was not easy to find, but careful testing of several alternatives which appeared promising finally revealed a unique method that proved adequate and satisfactory in both accuracy and cost.

The mapping required the participation of between 30 and 40 field crews and about 20 stereoscopic-plotter-machine operators. The Forest Service had only enough experienced topographic engineers to fill the key overhead positions. Additional engineers were not available elsewhere and professional foresters were the best that could be obtained to fill the more technical positions. Fortunately the men who could be made available had had some experience in plane surveying. Also they knew enough about life in the mountains so that they could get around and take care of their crews in the difficult redwoods. They responded rapidly to the intensive training that was given and readily adapted themselves to the requirements of the work. The forestry profession has reason to be proud of the performance of its men in another professional field.

Horizontal Control

The dense, giant redwood timber greatly complicated the job of establishing the ground control needed to obtain accurate map data from the photographs. True horizontal positions had to be located by triangulation from stations outside the timber. This meant that large signals had to be raised well above the tops of trees 175 to 250 feet tall so they could be readily observed from points as far as 30 miles away. Furthermore, all stations had to be precisely identified on the photographs, and the timber prevented doing this without special markers that would show on the photographs. White horizontal targets, therefore, had to be constructed in the tops of the tallest trees. Obviously all this required the services of a skilled high climber and rigger. George P. Lennon of the Hammond Redwood Lumber Company was employed for the work.

Between 350 and 400 pounds of equipment were required to build each platform signal. Because of this and the fact that all but one of the stations were off the road, 8 men had to be employed to back-pack the equipment and assist with the construction work. Three others were hired to back-pack bedding and food to the climbing crew at the many stations where an overnight stay was necessary. A few stations were so inaccessible they could not be reached in one day.

The crews ordinarily used big hollow trees as shelter from the wet, foggy weather at overnight camps. A hollow tree was found on one occasion that was large enough for four men to sleep in a circle around a fire, leaving sufficient room for two more beds.

A description of the work involved in rigging the first tree explains the techniques developed for constructing the high platform signals. That first tree proved to be the most difficult one selected. It was 18 feet in diameter and so large that the climber's 50-foot safety rope would not reach clear around the base. The climber had to go up the tree about 10 feet before he could flip the loose end of the rope around far enough to attach it to his safety belt.

The high climber quickly proved his adeptness by going up the first 50 feet, where there were no limbs, in less than 5 minutes. Then he worked steadily for 5 hours, cutting many large limbs and topping the tree about 230 feet above

ground. At times on his way up he used his 4-pound axe with such dexterity that 4 or 5 of the big brittle limbs would be falling at the same time. Although the climber did not release his safety belt and climb up to stand on the spar pole and rest after the tree was topped, he often did so on other trees.

After climbing and topping the tree, he spent 4 hours in rigging the signal. A light line, attached to the climber's belt and taken up the tree as he climbed, was used to pull up a snatch block and larger rope. The block was fastened to the top of the spar and used together with the rope to hoist materials. A vertical signal, consisting of a red and white flag, 5 by 14 feet in size, attached to a pole 35 or 40 feet high, was pulled up and raised above the tree spar. A white ply-board platform 6 by 16 feet in size was then built and securely anchored to serve as a target that would show on the photographs. The final step was to measure the height of the flag above a bench mark cut in the tree trunk just above ground. A 300-feet steel tape was used for this purpose.

When all of the platform signals were completed, the climber and a 3-man crew were kept busy setting flags in high trees that could be identified on the photographs without an artificial marker. Unfortunately more of these latter signals were needed than one climber could rig. Since experienced climbers could not be hired, several of the regular crew men had to be specially trained and assigned to the work. Some of the men who were selected had previously climbed a few poles and small trees; others had not even worn tree spurs before. But all accepted the risks and hard work without reservation and learned to do a satisfactory job. They did have their troubles, however.

One novice, thinking he could save time by not cutting all the limbs of a large tree he was climbing, unfastened his safety rope and let it go whole he pulled himself up onto a large limb. When he was ready to fasten the rope to his belt again, he discovered that he could not throw the rope around the large trunk far enough to catch the loose end. The limbs above were out of reach. After a frantic struggle he was finally forced to give up and send his partner to camp for an experienced climber who could help him down. He sat on his 125-foot perch from mid-afternoon until two o'clock in the morning when the other climber arrived to retrieve the lost rope and and help him down. An ordinary man who had gone through such an ordeal might have been unnerved to the point of refusing to climb again, but not this man. He climbed the same tree the following day and many others afterwards.

Triangulation work was started promptly after sufficient signals were established. One-minute transits and 10-second theodolites were used for the observing. The unusually large flags and the pains taken to elevate them well above the treetops made it possible to detect them with a telescope at distances up to 30 miles when visibility was good. Small, carelessly set flags could not have been observed.

The arrangement of topography and dense timber prevented triangulating all signals from regular ground stations. Some had to be "cut in" from a small rock island 6 miles out in the Pacific and from an observation platform built in the top of a high redwood.

The task of getting on and off the ocean rock was interesting and exciting. Men and equipment had to be transferred from a small skiff to an iron ladder on a sheer face of the rock while the ocean swell raised and lowered the water level 12 to 15 feet. A sudden storm accompanied by a choppy sea in the afternoon increased the difficulty of returning to the boat. But there was no misfortune other than a good soaking from the cold ocean spray bouncing back from the rock.

The tree-observing station required to complete the triangulation was constructed at a height of 215 feet above ground. This is believed to be the highest observing platform ever rigged for triangulation purposes. The tree spar was steadied with ½-inch wire rope, and the twisting motion of the platform was counteracted by guying its 4 corners with No. 9 wire. The sway was not entirely eliminated, but there was sufficient stability to permit accurate triangulation when the observing crew stood perfectly still.

Men were pulled into the tree by a ground crew of 5 using a No. 8 block and strong rope. This provided a real thrill for the men going up, particulary when the ground crew occasionally had to let them drop a few feet unexpectedly when they were dangling high in the air.

The successful completion of the horizontal control work was due in no small part to the development of unique methods to meet the

peculiar problems encountered. Although the costs were far above any for similar work in untimbered country, they were not deemed unreasonable for the redwood area.

Vertical Control

The use of a photogrammetric machine, known as the KEK strereoscopic plotter, for transferring accurate information from the photographs to the maps, required a large quantity of preliminary vertical control established by regular ground-survey methods. A minimum of 6 accurate elevations was needed for appoximately each 4 square miles, and at least 12 vertical positions were established whenever this was possible at reasonable cost. The difficulty and complexity of this work were increased by the necessity of distributing stations in or near the valley bottoms as well as along ridges and mountain slopes.

Basic vertical control was established by covering the area with a network of level lines of the third and fourth order totaling 901 miles. There were 4 to 6 lines crossing each 15 minute quadrangle.

Supplemental vertical control was obtained by several different methods depending upon the character of the topography and timber. Most elevations in relatively open country could be established by reading vertical-control angles from primary control stations to distant points which could be identified on the photographs. The horizontal measurements necessary to compute the differences in elevation were obtained by transferring the picture points to the base map and then scaling. More than 4,000 elevations were established in this manner.

Unfortunately the complex nature of the topography and the distribution of timber even in the more open country prohibited obtaining sufficient elevations by means of vertical angles. Numerous traverses had to be "carried" into canyon bottoms and timbered areas. In addition, all roads, railroads, and major trails were traversed. These latter traverses were closed within 2.5 feet. The more difficult cross-country traverses were closed within 5.0 feet.

The vertical work on the easier sections of the unit was bad enough but came nowhere near approaching the difficulties encountered in the dense, old-growth redwood timber. The scarcity of roads and trails within the redwoods plus the impediments to foot travel and the occurrence of almost continuously wet weather resulting from dense low fogs made the physical aspects of the job exceptionally difficult and disagreeable; likewise unusual technical difficulties were encountered. The dense timber prohibited establishing accurate elevations at frequent intervals by the more simple means of photographic identification. Intensive research proved that the work must be accomplished by running precise profile traverses and transferring the information to base maps. Lines were located on the overlap of adjacent photograph strips and through the centres of photographs along the direction of flight. Thus three lines occurred on the territory covered by each photograph.

These profile lines were started from known horizontal positions and bench marks along the coast highway. They extended 4 to 15 miles in land to the eastern edge of the dense redwood timber, where they were tied to accurate control stations. Ties were also made to intervening stations along the lines wherever possible. These intervening stations consisted of the high redwood signals and points that could be accurately identified along creek bottoms. The majority of lines had ties at intervals of 3 miles or less; none extended more than 4 miles without a tie.

Traverse Methods and Costs

Traverse methods were varied in accordance with (1) the distances necessary to run without making closures, and (2) the qualifications of instrument men. The longer and more important lines were run with Beaman-arc Dietzgen mountain transits. Distances were measured by stadia. Only proficient transit men were assigned to this work. Since the majority of the party chiefs were experienced plane-table men who could not qualify as transit men, most of the lines were run by compass bearing using a plane table and Beaman alidade. Stadia measurements were made and positions were plotted on a scale of 1:15,840. This method, however, was confined to those lines where closure could be made at least every 3 miles.

A system of automatic checking was used to insure against the need of rerunning lines. Although additional work was required by this system, it proved well worth while because all lines were closed both vertically and horizontally without rerunning. This is important

considering the fact that each line took anywhere from one to four weeks to run and cost between $250 and $1,100.

The unusually high costs were due primarily to the nature of the country. Dense brush required continuous slashing on all but a small portion of the total distance traversed. The slashing ordinarily took much more time than the instrument work. Crews were often unable to complete more than half a mile a day because of the amount of brush that had to be cut. The scarcity of roads and trails together with the extreme slowness of cross-country foot travel necessitated the use of back-pack camps the majority of the time. This in itself contributed much to the high costs, but even so was the quickest and cheapest method.

A New Experience

"Camping with the work" was a new experience for nearly all the men. They had to adjust themselves completely to the vigorous life of staying out in wet weather from one to four weeks at a time with a minimum of food and bedding. But a co-operative spirit and sheer determination predominated, and with the help of close supervision the men soon learned to plan and organize their work effectively.

An interesting incident experienced by one crew during a miserable foggy night denotes the hard work and discomfort that the men willingly accepted in order to complete the job in a minimum of time. After backpacking heavy loads nearly all day and working until dark to complete a line, the men found themselves high on a ridge top without any water. They decided to hike down from the top to find water and make camp where they would be out of the cold fog for at least part of the night. But after feeling their way for nearly a mile down a steep slope without finding water, they decided the "tired team with its heavy load" could get by for the night in a dry camp, so they stopped at the first level spot. After choking down some supper and while sitting around the fire about midnight trying to enjoy an after-dinner smoke and forget their craving for water, a small skunk came by on a tour of inspection. He ran to within 3 or 4 feet of the fire before he stopped to size things up and decide he belonged elsewhere. This created an interesting diversion for the men and made them realize that water should be near. It was. And no coffee ever tasted better than that brewed over an open fire at one o'clock in the morning.

Value of Project

The nation can be thankful that these detailed topographic maps were not needed in combating Japanese invasion forces. But even though they are never needed in warfare, they will be highly beneficial in the future use and development of the many valuable resources of the territory. The benefits to forestry and the timber industry alone will fully justify the cost of the work, for the unit contains some of the finest virgin timber left in this country. There are billions of feet of redwood, fir, cedar, and spruce that will sustain large-scale logging operations and require intensive forestry for many years to come.

—*Journal of Forestry*, Vol. 43, No. 4, dated April 1945.

PHYSICS IN AGRICULTURE

By S. C. Bhatnagar, B.Sc. (Agr.), B.sc. (Ag. Engr.).

The most outstanding contribution made by Physics to Agricultural science is in the study of soils. The soil is a complex mixture of solid, liquid and gaseous material. Mineral and organic matter form the solid phase. Water varying in chemical composition and the freedom with which it moves forms the liquid part filling a part of the pore space. The remaining porespace is filled by vapour. The study of the mechanical behaviour, the laws governing water supply, movement and retention, affect directly the plant growth.

Sir Humphry Davy (1813) was one of the first to study the physical properties of soils. Schubler followed 1833) and wrote a book on soil productivity and their physical concepts. He found out the specific gravity and water-holding capacity of soils and its effect on volume. He described the heat capacity of soils including the effect of sunlight. This was followed by Schumacher (1864) who stressed Schublers works. Much interested in air and water movement in soils, he advocated the idea of capillary porosity. In 1877 Wollny wrote a monograph

on the various soil properties affecting plant growth. He conducted various experiments by which he measured the interception of rainfall by foliage and its effect on runoff and erosion in plots of various slopes, soils, and vegetation cover conditions. He studied the various field operations, *i.e.*, ploughing, cultivating etc., in connection with their results on the plant and on the soil. About the same time some American scientists made outstanding contributions to the knowledge of Soil Physics. Hilgard in 1873 made an elutriator for making silt analysis. To help in water storage in soil Johnson (1877) advocated tillage practices. He studied capillary transmission and evaporation. (He gave more emphasis to the rate of movement than the distance of travel finding that water moves faster in moist and big pore soils than in dry and small pore soils. King (1888) found out the water requirement of various crops. He advocated the conservation of water by means of dust mulches produced by tillage. His theory of dust mulch was based upon evaporation losses from columns of soil in contact with free water surface. The conservation of moisture was due to tillage practices by increasing the water-absorbing capacity and checking its escape by means of evaporation and transpiration through the weed leaves. Briggs worked on the mechanics of soil moisture. Buckingham worked on capillarity and the oil moisture movement. Patten made important findings on transference of heat in soils. From 1920 the interest in the physical properties was again revived. Most outstanding works of the recent days are by Keen and Handbuch der Bodenlehre.

The above is in short the history of the development of Soil Physics. The modern soil physics is a growth of the past twenty-five years. It is very interesting to note as how many loop-holes exist in a pure science when it is applied to practical problems, and how strangely findings of one can be applied to another. Soil physicists at Rothamsted worked out the mode of distribution of water films within a porous material, which was a problem of pure physics. The researches in physical and physico-chemical properties of soil and clay which were solely worked as problems of soil physics have important bearing on the Ceramic industry, in the preparation of flour dough, butter, cheese and tooth-paste making.

From the physical point of view soil is a mixture of particles of all sizes and shapes and is generally referred to soil texture. Fine gravel (grit) have diameter of particles ranging from 2 to 1 mm. while clay has diameters ranging from .005 mm. and below. This shows the great variation from 2 mm. to minute particles. A soil material may be subdivided into fractions according to size of its constituent particles which is called the mechanical analysis. The determination of size of particles and the study or other physical properties are not only of interest to soil physicist but to Engineers and all the more to Agricultural Engineers who are mostly concerned with problems involving soils. Construction of soil-saving dams, irrigations, canals, channels for drainage, foundations of buildings having quite a bit do with texture of the soil. In a mechanical analysis firstly the bigger particles are removed by sieving while the other finer particles are removed by some form of dispersion method. To describe the various methods for determining the mechanical analysis is beyond the scope of this article.

Clay is the most important of all soil constituents. It is often subdivided into small fractions called ultra clay or colloidal clay. Many of the physical and chemical properties of soil are dependent upon the surface activity of the clay fraction. It has marked colloidal activities because of large amount of surface per unit weight of material. Sand and silt are primarily quartz or unweathered minerals which make the surface activity low. At Missouri they found out that coarse silt (20 μ to 5 μ dia.) possess only 1/10 of surface properties of coarse clay (2 μ to 1 μ dia.) and less than 1/20 of the absorptive capacity of colloid clay (less than 100m $\mu = 1\ \mu$).

Clay soils retain water for a considerable time and drain with difficulty. Because of the higher moisture content they warm up less rapidly during the hot season and cool slowly in winter. The most important of all the properties is the crumb formation which consists of many individual particles bonded together by electric forces associated with the charged spots on the particles surface and with the neighbouring Ions. These soils shrink while drying thus during dry weather soils crack which is harmful especially if a crop is standing on such a soil. When wet such soils cannot be worked without injuring the tilth of the soil.

By good tilth we generally refer to the pulverant condition of the soil which results from good tillage. It may be referred to a condition which all good farmers look forward to grow

crops successfully. It is because of many factors of which the most fundamental is a good crumb structure. It is very closely related to aggregate formation since it is associate to the colloidal material. Sandy soils because of the size of the grains are well drained and are very seldom in bad tilth, but are very poor in storing moisture and food nutrient.

Organic matter plays a very important part in contributing to the aggregation of the soil. Its action is cementing in nature which is most probably due to a kind of adsorption of the humus by the inorganic soil colloid which brings, about a stable union between organic and inorganic material with the help of dehydration. It is the decomposition of organic matter which is responsible for the structure formation in place of organic matter itself. According to Russel the more rapid is the decomposition the better is the structure. It has been found at Indore that addition of organic matter may improve crumb structure and finally the crop yield.

The growing crop affects soil structure in two ways. (1) Directly the plant leaves and stem protect the soil from the direct impact of rain drops which prevents the dispersion of the soil. Plant roots by binding action, by change of moisture percentage, by absorption and possibly by root excretions develop granulation and porosity. (2) Indirectly the crop provides organic matter which changes the granulation. Extra to organic matter the cementing material in certain soils such as laterite soils may be iron hydroxide, colloidal alumina may also aid in aggregation structure. Plant roots and soil can be imagined to have barter. The roots give off CO_2 and provided hydrogen is in intimate contact with the clay surface on which Ca, Mg and K and others are absorbed. The hydrogen from the root is a positively charged ion and exchanged for similar charges on clay. These positive ions on going into roots are synthecised in complexes which are carried up the plant. The humus is of great help in soil productivity. It works like clay because of the great absorptive surface. It too can exchange its hydrogen for nutrients in mineral. In addition it decays rapidly and give plant food of which it was originally constructed.

Cultivation of soil affects the soil structure in the following ways :—

Tamahane and Sreenivasan give the following reasons as how the structure of the soil is changed because of the cultivation. (1) It decreases the organic matter production. (2) Increased organic matter decomposition. (3) Increase in leaching. (4) Effect of the direct impact of rain drops on the soil. (5) Effects of the mechanical manipulation of tillage implements.

Plasticity, cohesion and surface friction between soil and metal surface of an implement influence the pull considerably. At Rothamsted they found out that in a plot 66 ft. by 33 ft. the draw bar pull varied up to 30 per cent. Such a variation is of great importance in comparative of competitive implement trials where it is essential to conduct the preliminary dynamometer survey. Other experiments show that addition of manures other than organic manure did not bring about any change. They found out that the drawbar pull is comparatively unaffected by the speed of the cultivation. An increase of speed from 2.25 miles to 3 miles per hour which meant 60 per cent. extra work required 7 per cent. increase in drawbar pull which resulted in saving the time and money due to increase speed. Such experiments call for better design of tractor to work satisfactory under higher speeds.

SOIL AND WATER RELATIONSHIP

Water, its movement, retention and losses is of very great importance for the plant growth not only because, itself being a part of food, but as a carrier of soil nutrients. Dr. Keen describes the flow of water through soil as analogous to flow of heat or electricity through conductors which gives a great difficulty because the quantities corresponding to conductivity and potential (which for the heat and electricity are practically independent of the external condition and current density) are not independent of the moisture contents which dependent upon the state of packing and the colloidal content of the soil.

Soil water can be classified into three groups, *i.e.*, hygroscopic, capillary and gravitational. Many authors who regarded soil grains as inert units led them to subdivide these main groups still further, but the recognition of the soil properties as that of colloids has destroyed the validity of such additional groups. Hygroscopic water.—When dry soil is exposed to atmosphere it absorps moisture rapidly until the molecular attraction of the colloidal surface

is satisfied. After the moisture absorption is done this soil can still hold some water in liquid form if added to it. This water held by the soil is called the capillary water. If the addition of water is continued the capillary capacity is full and free water starts moving down because the action of gravity.

The capillary porespace can be divided into two parts. (1) Micro porespace.—This is the porespace present in the crumb. (2) Macro porespace.—This is the porespace between the two crumbs. The inner capillary water is controlled wholly by the colloidal nature of the soil while the outer capillary water is held because of surface tensional and colloidal nature. There are four important factors which affect the amount of the capillary water. (1) Texture of the soil. (2) Structure of the soil. (3) Organic matter present in the soil. (4) Action of gravity.

The literature on soil water relationship reveal two schools of thought which differ slightly. The older concept is the capillary tube hypothesis which pictured the porespace of the soil as a set of capillary tubes varying in length, width and direction. Water relationship was thought as a function of the tension of the water films around particles. E. Buckingham, another representative of the Bureau of Soils, advocated the using of energy relations to explain soil moisture relations, which was further developed by Gardner, Haines and Keen. This has modified the old thought of capillary tube hypothesis just a bit.

FAILINGS OF CAPILLARY TUBE HYPOTHESIS

The early workers in explaining the water relationship missed the implication of two sets of porespaces. They applied the ordinary capillary tube formula of pure Physics which states that the height of the miniscus is inversely proportional to the radius of the tube showing that the smaller the diameter of the tube the greater will be the height of miniscus. This led many to believe that as plants absorb water from the soil the water is replenished by capillary movement from the water table. All experiments conducted in the laboratory failed to show greater rise than three feet. These experiments were rejected by some on the ground that the failure may be due to uneven packing of the soil. At Rothamsted to avoid the soil packing factor they sunk iron cylinders six feet long and two feet in diameter in earth and filled them back with the soil in the same order as it had been excavated. These iron cylinders had observation tube on one side. For few years the soil was allowed to settle before any observations were taken. During the winter these cylinders got water logged. The descent of the water level was observed from the observation tube during spring and summer for several years. The results show that capillary rise was two feet in fine sand and three feet in ordinary soil. Leather in an article on the loss of water from soil during dry weather as early as 1908 published in the Memoirs of the Dep. Agr. Ind. pointed out that during dry periods water moves upward towards the surface of the soil from a limited depth only and is lost from the soil by evaporation. Barker at Nebraska Station found that the loss of water due to direct evaporation from the surface of the soil is a very small factor after the water becomes thoroughly distributed in the soil.

There are four forms of water movement. (1) Diffusion. (2) Film adjustment (3) Percolation. (4) Thermal movement.

1. Diffusion.—This movement is because of unequal molecular attraction towards the point from where the water has been removed. This movement is rather slow but is the only way by which the moisture may be available to plant roots after they are isolated from the free capillary water.

2. Film adjustment.—This is also known as capillary movement. It is due to stress of pull developed by surface tension from the thick films and wedges to those that are thin. This has been discussed in detail just above.

3. Percolation.—It depends upon the texture and structure of the soil. In sandy soils water percolated much quicker than in clay soils, other factors being the same. The drainage problem has quite a bit to do with the percolation power of the soil. In soils where percolation is poor, the tile drains are put much nearer the surface than in light soils.

4. Thermal movement.—This is divided in two classes. (*i*) Internal thermal movement.—This refers to the movement of water vapour in the soil. (*ii*) External thermal movement—This refers to evaporation.

PROBLEM OF MOISTURE CONSERVATION

The average rainfall for India is 37 inches, which is more than sufficient for ripening of a normal crop other than such which require heavy irrigations like sugarcane or any other vegetable crop. Our ignorance about the principles affecting moisture conservation are mostly responsible for low yields. In a country like India where out of the total cultivated land only 16 per cent has provision for artificial irrigation, it is all the more essential that our cultural methods should aim at largest conservation of the moisture.

METHODS OF SOIL MOISTURE CONSERVATION

1. Increasing the absorptive power of the soil.—The first problem is to take care of all the moisture which falls on the soil in the form of rain. The irrigation commission reports that more than 35 per cent. of rain goes back to sea in our country where the soil just refuses to grow crops because of lack of moisture. Absorption of rain can be increased by leaving the soil open and rough so that it can take care of all the rain falling. This will check run off and erosion. When soil conditions are favourable for moisture absorption and the intensity of rain is not excessive very little water will be lost.

2. Increasing the water-holding capacity.—Organic matter plays an important part because it increases the water-holding capacity. It acts as a sponge in absorbing rain water.

3. Checking the loss of moisture from the soil.—Water loss starts immediately after the rain has stopped. If the soil has plants growing over it the moisture is lost by transpiration and evaporation. Soils free from plants have very little loss of moisture, actually there is very little loss of moisture from lower second feet except under very warm conditions. At Indore experiments were conducted on shallow versus deep interculture practice for a number of years and they came to conclusion that shallow interculture, just sufficient to keep down the worst weeds has yielded best, while the excessive interculture resulted in injury as the soil structure was spoiled because of the trampling of the soil.

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—*The Allahabad Farmer*, Vol. XIX, No. 2, dated March 1945.

A TREE PLANTATION PLAN FOR NORTHERN INDIA

1. THE PLAN

M. S. Randhawa, I.C.S.

Secretary, Imperial Council of Agricultural Research

Just as we are planning the development of industrial and agricultural resources of our country, we should also have a national plan for encouraging the growth of fruit and ornamental trees. In drawing the plan we have to consider the choice of trees for each climatic zone of the country and also take into view the soil and irrigation factors. We have also to clarify our ideas regarding the choice of trees for various purposes, *e.g.*, planting roadside avenues, city roads, canal banks, public parks, platforms in railway stations and compounds of private houses. We have to assign ornamental flowering trees, shade trees, timber trees and fruit trees to places where they can best fulfil their function. At present we see the irritating

spectacle of fruit trees being grown indiscriminately in the compounds of houses, and timber trees in public parks and city roads.

The plan

In brief we may sum up our tree plantation plan for India as follows :

1. Bio-aesthetic planting for compounds of private houses, dak bungalows, banks, hotels, universities, colleges, schools, public offices, town roads, public parks and platforms of railway stations. For these places we should select trees with beautiful flowers and foliage to beautify them and to give pleasure to the people. *Kachnar*, pink cassia, erythrina, milletia, *amaltas* and gold mohur come under this category.

2. Road-side avenues of our national, provincial and district highways. The sole criteria for selection should be shade plus economic utility. For this purpose, trees which yield timber, fruit and are also shady should be selected such as *mahua*, mango, tamarind, *neem* and *sheesham*.

3. Canal Roads. We should plant all canal roads with fruit trees like mango, *jaman* and *kathal*. The stones of varieties like *langra*, *dussehri*, *sufeda* and *fajri* yield excellent fruit trees which are better than the *desi* mango. There are thousands of miles of canal roads which can be planted with fruit trees thus adding a valuable source of vitamins to the deficient dietary of our people.

4. Village plantations. Fruit, timber, and fuel are the main requirements of villages. Let them plant fruit trees like mangoes, lemons, papayas, *kathal*, and sweet limes in the compounds of their houses, *phulwaris* and along the bullock runs of their wells fitted with persian wheels. They should be encouraged to plant *bakain* and mulberry trees in the compounds of their cattle shed. Mulberry twigs are used for making sturdy baskets which are so useful in the cattle-shed and the house of the villager. Both these trees are commonly grown by Punjabi peasants in their cattle-shed, though it is so rare in the United Provinces, in spite of the fact that the climate is favourable for their growth.

Ideal Village Plantation

Village *shamilat*, the common land which is used for pasturing cattle, is ideal for village plantations. Old fallow land which has been out of cultivation for a long time can also be taken up for plantation purposes. The question is whether these plantations should be raised and managed by individual farmers or by the village *panchayat*. Plantation under the supervision of the *panchayat* and common ownership of the trees is on ideal solution, but the difficulty lies in the lack of corporate sense in many villages. Usually we find that everyone's responsibility is no one's responsibility and trees planted with great effort are grazed by cattle. So we have to adopt both the remedies. In a village, where a *panchayat* is functioning successfully the plantation should be raised by the *panchayat*, which can also appoint village young men as guards for protecting the trees in the first two years.

In the zemindari and taluqdari villages of Oudh the waste-land belongs to the zemindar or the taluqdar and not to the cultivator. This is the biggest obstacle in the way of tree plantation programmes in these villages. The tenants cannot be expected to plant trees for the benefit of zemindars and the zemindars are either too lazy to take up the plantation work themselves or the area of waste-land under their control is too vast and scattered to be planted by them successfully. To overcome this difficulty in the way of progress, the proprietary rights in the waste-lands must be given to the village *panchayats*.

Individual Plantation

In some villages it would be more feasible to partition the village waste-land into units 1 to 5 acres in area. These plots should be enclosed by *kutcha* walls to give protection to young trees. Where water table is fairly high a *kutcha* well may also be dug in the plot. Near the boundary wall thorny fuel trees like *babul* or mesquite (*Prosopis juliflora*) may be planted. In the middle area fruit trees like *desi* mango and *kathal* may be planted. The fruit trees may occupy 25 per cent. of the area and the remaining should be covered by fuel and timber trees.

Choice of Species

For an ideal village plantation we require trees which provide fuel and fruit as well as small timber for agricultural implements. So the species selected must be fast growing, easily grown and good coppicers. The following species are recommended :

For fuel and timber:

1. *Babul* can grow almost anywhere in dry waterless tracts, eroded ravines and on marshy banks of *jhils*. Yields excellent fuel as well as fine timber for agricultural implements and wheels of bullock-carts. Bark is used for tanning leather.

2. *Shisham* yields excellent fuel and timber and is fast growing. It has been used extensively for covering sand-covered fields along the banks of Chos in Hoshiarpur district and is a good coppicer.

3. *Bakain* is a very fast-growing tree and yields insect-proof timber for ploughs.

4. *Mesquite* can easily grow on sandy and rocky soil.

5. *Dhak* will grow on the worst soil and can even tolerate mild *usar*.

6. *Bamboos* can easily be planted near ponds. Bamboo has many uses in the farm.

7. *Mulberry* (only *desi* 'Toot') should be encouraged.

Fruit trees:

1. *Desi mango*. Good varieties of *desi* mangoes with thin juice and good flavour should be selected and grown.

2. *Kathal*. In area with rainfall over 30 inches *kathal* trees should be encouraged.

3. *Mahua*. A popular tree in Oudh and is valued for its fruit as well as wood. It can grow on mild *usar*.

4. *Jaman*. The variety with big-size fruit, known as *ra-jaman* should be encouraged. This is one of the few trees which can stand waterlogging and can be grown on areas liable to be flooded.

5. *Imli* yields edible fruit as well as excellent coal for producer-gas engines.

Celebrating a tree-plantation week

Considering the area of the country the tree-plantation plan which we have outlined is so gigantic that only a nation-wide effort can be expected to produce any results. Individual efforts, however extensive and however zealous, cannot produce a visible effect. There is so much ugliness all about, so many *neems* and *shishams* that little patches of colour which an individual may produce are likely to be swamped in an ocean of ugliness. How should we set about this colossal work? There is a necessity of growing nurseries of flowering trees in important towns. There is need of such nurseries in every town, and every village of sufficient size and importance. When nurseries are established in Government, Municipal and Railway gardens, and in the compounds of Dak Bungalows, hotels, schools and *panchayat ghars* in villages, and we have produced sufficient number of saplings we can start planting work by celebrating a tree plantation week' in the end of July, when rains have set in northern India.

While posted at Rae Bareli as Deputy Commissioner from 1941 to 1944 the present author initiated the celebration of such 'tree plantation weeks'. All preliminary work was usually completed in the month of May. Sites for digging pits were selected in the compounds of public buildings such as Collectorate Office, District Courts, Municipal and District Board buildings, *tahsils*, schools, platforms of railway stations, houses of leading land-owners, and *panchayatghars*. Digging of pits, their manuring and filling was completed in the month of May and indents for plants were collected from all departments and leading land-owners and a collective order for supply of saplings was placed with Government Gardens Lucknow whose Superintendent Victor Sane displayed a good deal of interest in the propagation of ornamental trees. Distribution of saplings and collection of bills was done through *tahsildars*. In the last week of July every year the plantation week was inaugurated with great enthusiasm and all persons of importance participated. Co-operation was received from all departments.

Planting flowering trees

The co-operation of the District Boards who control a network of village schools dotted all over the country-side is very essential. Griessen mentions the existence of a 'Society of the Friends of Trees' in Tunis in French North Africa whose function is to bring together all people who love trees and are interested in encouraging their plantation. He states that packets of seeds of selected trees were supplied each year to the students of schools which were sown during a selected week. We should also organize a society of lovers of flowering trees to bring together all people who are interested in the propagation of beautiful trees. Such a society ought to be organized under the auspices of the Rural Development Department and should form an important section. Seeds of *kachnar* spathodeas *amaltas* gold mohurs

erythrinas and other beautiful trees should be collected through the agency of the Horticultural Department and supplied to various schools through their inspectors in pictorial packets containing a description of the tree with directions about planting. When the school work is inspected the Inspector should see that the school teachers take sufficient interest and those who show good work are encouraged by grant of certificates sanads cash prizes and good entries in their character rolls. It need hardly be emphasized that all manual work such as digging of pits manuring and irrigation should be done by the students and teachers rather than by hired labourers. Spades and *khurpas* should be provided to all schools at Government expense and persian-wheels should also be fitted on wells where the water level is suitable.

Fruit and timber trees

A 'Tree Plantation Week' need not necessarily be confined to the plantation of flowering trees only though it should form an integral part. Plantation of timber trees like tamarind *neem, bakain, shisham* and *babul* on waste land, and of fruit trees like lemons, sweet lime, papaya; *amlas, kathal,* mangoes, and bananas in gardens in and the back-yard of compounds of houses should also form an essential part of the programme. Thus we will be increasing the wealth of the country by planting timber trees, and improving the health of the people by providing them with vitamins in their dietary by planting fruit trees, and will be elevating their souls and developing aesthetic consciousness by planting beautiful flowering trees.

—*Indian Farming*, Vol. VI, No. 8, dated August 1945.

VOLUME 72 NUMBER 3

INDIAN FORESTER

MARCH, 1946

SOME AFFORESTATION PROBLEMS IN THE PUNJAB PLAINS *

BY A.P.F. HAMILTON, M.C., O.B.E., I.F.S.

(*Chief Conservator of Forests, Punjab*).

Although the localities dealt with lie in the "under 10 inches" rain belt, they differ from the greater part of the desert fringe tract, for which a series of afforestation experiments are being undertaken by the Punjab forest department under the direction of the Central Silviculturist, in that the water table is high and rivers flow at no great distance. Nevertheless there are certain soil types of a highly refractory nature which present real problems.

I. Afforestation in the Sind Sagar Doab

Situation.—The tract lies in the south-west of the Punjab above the confluence of the Chenab and Indus rivers; the forests concerned lie on the old bed of the Indus.

Climate.—Intensely hot and dry in the summer, with maxima up to 120° F. Winter cool with occasional ground frost.

Rainfall.—Average annual rainfall—5 inches; most of which falls in the monsoon. Not only does the total vary very considerably, but showers are very local; parts of the tract dealt with may be rainless throughout the year, while others may receive a good wetting.

Soil types.—The soil consists entirely of alluvium, but varies very considerably in character, often over short distances.

The following types are distinguishable—

(*i*) *Milkh.*—A fertile clayey loam of considerable depth either overlying pure sand or communicating direct with the water table.

(*ii*) *Gaser.*—Light sandy loam not deeper than 6 ft.-7 ft. and overlying pure sand.

(*iii*) *Draman.*—A thin layer of clayey loam up to 1½ ft. thick, overlying pure sand.

(*iv*) *Thur* or *kallar.*—The loam crust as described in (*i*) and (*ii*) is saline in varying degrees of intensity, the salts being mainly concentrated in a zone near the surface.

(*v*) *Rakhar* (*rappar*).—Saline soils in which the normal 'calcium'-clay has been converted into a 'sodium'-clay and with a high pH value. Characterised by high impermeability, but intensity varies; occurs usually as a shallow stratum in loams. This type of soil is liable to hold stagnant water.

Moisture factors.—The depth of the subsoil water level varies with the distance from the river and with the season. The highest cold weather level is about 6 ft. and the lowest about 12 ft. The rise of the river in the hot weather brings the water to the surface near the river and to about 8 ft. from ground level at the furthest point from the river.

Natural irrigation is afforded by inundations from flood water over a considerable area, and it is to this that the present crops of any value owe their existence.

In *draman* areas drought conditions prevail permanently except where the subsoil water level is high or the land is subject to inundations.

Evolution of the principal natural forest crops.—The Indus river is tending to move westwards, and in doing so, it has left behind numerous branches which help to inundate the newly-formed land. This land, which is called *kachi*, receives fine layers of silt annually from inundations. The pioneer species which invade this land are *pilchi* (*Tamarix dioica*) and the grass *kahi* (*Saccharum spontaneum*). As the *kachi* becomes elevated, *poplar* (*Populus*

*Paper presented at the 6th Silvicultural Conference, Dehra Dun (1945), on item 6—*The Afforestation of Dry and Desert Areas.*

euphratica) and *babul* (*Acacia arabica*) come in; the land is now established, though still liable to inundation, and is called *pakki*. So long as inundations continue *poplar* and *babul* flourish. Moisture conditions, both surface and subsoil, deteriorate as the land becomes elevated and the river recedes, and the *poplar* and *babul* crops open out and give way to *munj* (*Saccharum munja*) and *sissoo* (*Dalbergia sissoo*).

Forest crops of the above types have been managed successfully for a very long time, but they have flourished mainly where the soils have been favourable. Considerable areas of *thur* and *rappar* land exist which it has not been found possible to afforest up to the present; these areas are mainly old *pakki* which have been abandoned by the river a very long time ago. In addition, considerable areas of crown waste, much of which carries these unfavourable soils, have recently been taken over by the forest department after being discarded as unfit for cultivation. A few scattered trees of *jand* (*Prosopis spicigera*), *babul*, *ber* (*Zizyphus jujuba*), *wah* (*Salvadora oleoides*), *karir* (*Capparis aphylla*) still exist on these lands.

It is the afforestation of these areas which is going to be the chief problem; but fortunately canal irrigation has been promised and the reclamation of much of the saline land will be possible.

The silvicultural problems are:—

(*i*) *In the saline soils 'thur' and 'rappar'*

(*a*) *Where canal irrigation water is available*, to reclaim these soils by leaching and to find out the minimum water requirements for reclaiming mild and strong *thur* and *rappar*.

In this the assistance of the irrigation department is being obtained, but the procedure will probably be as follows:—

The application of a 5 ft. delta of water annually for 3 years, with 3 crops of rice. This is the general practice followed in the reclamation of *thur* land for cultivation, with variations in the amount of water given. The effect of the heavy watering is to wash the salts down to a level beyond which they will not be affected by the upward movement of water due to surface evaporation, the Irrigation Research Institute has established the fact that from below a depth of 10 ft. (this includes a margin of safety of 3 ft. to 4 ft.) no moisture moves upwards as a result of surface evaporation. Generally speaking a 5 ft. delta given for 3 years will clear the soil of salts down to this level. Rice flourishes in moderately saline soils and not only serves as a valuable catch-crop, but it also breaks down the unfavourable 'sodium' clay conditions and reduces the pH value.

Saline soils thus reclaimed are expected to remain sweet permanently unless an unexpected rise in the water-level should bring the salts up again.

Various species will be tried, but since the saline soils are usually those with a high proportion of clay, *babul* is likely to be the best species where high intensity saline soils have been dealt with, and *sissoo* should succeed where the intensity is lower.

(*b*) *Where canal irrigation is not possible.*—Soil tests will be taken to determine the maximum degree of permanent salinity which *babul*, and probably *Prosopis* species can stand. Samples of saline soil carrying naturally-grown *babul* trees have already been collected for test by the reclamation staff.

(*c*) *Draman* (*shallow clay crust over pure sand.*)—The important point about this soil type is that the crust contains little space for root development owing to its shallowness, while the sand substratum contains no available moisture at all unless the area is liable to inundation and then only when inundation water is present. *Draman* lands are usually avoided by cultivators. In inundated *draman* areas occasional *Zizyphus* and *babul* trees have been observed, and it is believed that where a soil crust of not less than 18 inches occurs it will be possible to raise economically crops of *Zizyphus*, *babul* and *siris* (*Albizzia spp.*) though the silvicultural technique has yet to be worked out; naturally the higher the water table the greater the chances of success.

(*d*) *Where the soil is good and deep, but no surface water is available and the water table is at its lowest.*—The problem here is to get the roots of the trees down to the subsoil water, with an average annual rainfall of 5 inches. It is not an easy one and no experiments have been undertaken yet, except those started under the direction of the Central Silviculturist, but where these are situated the mimimum average annual rainfall is 8 inches. However these experiments will show which species are most suited to desert afforestation, and by using the most rigid moisture conservation measures, it should be possible to raise a forest crop.

(*e*) *Dry draman, where neither surface irrigation nor inundation are possible.*—This type is without natural tree growth, and chances of success are poor; but it will be worth trying arid types of *Prosopis*, and *Acacia jacquemontii*, which later thrives in conditions combining low rainfall and sandy soil.

II. Afforestation in the Chenab riverain or 'bela' lands

Higher up the Chenab river soil conditions in the riverain area are far more favourable than in the Sind Sagar Doab and there is a slight but progressive improvement in the rainfall.

Natural *sissoo* forests are to be found throughout the course of the river and they have been under management for a long time. But about 10 years ago the afforestation of fresh *bela* lands was begun and a working plan has been drawn up.

Much the same subsoil moisture and inundation conditions prevail here as in the Sind Sagar Doab, and the present forests have been formed in much the same way; but here the soil is deeper and more fertile, salinity is rare, and *sissoo* can be grown almost everywhere.

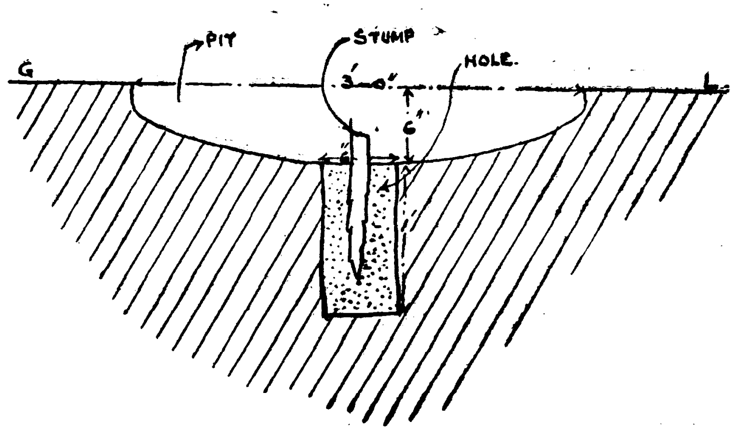
First attempts at afforestation.—The great success of stump planting in the irrigated plantations pointed to their use in the case of the *bela* plantations also. Stumps were planted 6 ft. apart on the berms of trenches 12 inches wide and 6 inches deep, dug 10 ft. apart over the entire annual coupe and at the beginning of the monsoon. This method proved a failure for two reasons: in the first instance the young plants which had only just sprouted on lower lying areas were swamped by the inundations, while those on the higher land were killed by the usual drought which begins at the end of the rains, often from the end of August. The regular watering given to the young crops in the irrigated plantations was absent in this case; it was, furthermore, believed that the trenches had drained the mositure away from the plants instead of conserving it for their use, but proof of this is wanting.

It was then realised that planting must be done as early in the season as possible for the dual purpose of developing the roots of plants on the higher ground to resist the autumn drought and the shoots of the plants on low ground to stand above the floods. The present technique which is proving most successful is as follows :—

Season.—Planting begins on March 1st, in pits previosuly dug, and is completed in 2—3 weeks.

Type of pit.—These are called 'boat-pits', and the diagram below describes them. They are 1 ft. wide and the trough-like bottom is designed to make the maximum amount of rainfall available to the plant, while their shallowness reduces the danger of water stagnation. The plants are placed in the hole in the centre of the trough after a certain amount of earth has been placed in it, then earth is tramped down all round.

DIAGRAM ILLUSTRATING 'BOAT PIT' TECHNIQUE.



Watering.—To secure survival and rapid growth during the hot weather, the plants are hand watered, once in 7 days, until the rains break, or longer in case of their failure. For this purpose small *kacha* wells are dug one per acre and have been found the moste conomical. At each watering half a kerosine tin of water is given to each plant, and a coolie can do about 100 plants per day. After watering stops at the beginning of the monsoon the pits are expected to make sufficient moisture available.

Cost of afforestation— Nature of work.	*Cost per acre* Rs.
1. Burning and stubbing out *kana*	13
2. Digging pits and holes ..	9
3. Planting	3
4. Digging wells	12
5. Watering	48
6. Weeding	4
7. Cost of stumps	1
Total ..	90

Watering is not required in the second year as the roots of the plants have by then reached subsoil water level.

INTRODUCTION OF GRAFTING IN NATURAL REGENERATION

By R. N. Garge

(*Range Forest Officer, Jalgaon, East Khandesh Forest Division*)

It will not be out of place and time to discuss the possibility of the introduction of horticultural methods in rearing plantations in forest areas which naturally abound in fruit trees, when there are proposals for post-war reconstruction throughout all the provinces. It is an acknowledged fact that the recent war has changed our outlook and called in question the desirability of concentration of attention in the past on only the important timber species with regard to their economic aspect to the utter neglect of inferior soft species. War has brought to light many inferior species and their importance is increasingly being realised in the future industrialization of the country. It is a welcome idea inasmuch as it vouchsafes the utilization of the natural flora of the tract in its rearing with comparatively less cost. On a similar basis, it is proposed here that if the tract naturally abounds in important fruit trees, it will be more practical and economical to concentrate attention on the best method of their rearing with a view to realise additional income from such areas with due regard to transport facilities and the marketing conditions of the tract.

Important fruit trees such as *Mangifera indica*, *Eugenia jambolana*, *Zizyphus jujuba*, *Phyllanthus emblica* and others, have intensive coppicing power. In the clearfelled areas which have a definite preponderance of fruit trees, it is possible to graft their coppice shoots with a better variety of the same species. To what extent the above proposition is economical can be seen from the following illustration:—

Jalgaon Range in east Khandesh division consists of scrub forest growing *khair* (*Acacia catechu*), *ber* (*Zizyphus jujuba*) and other thorny species characteristic of the scrub area. The forest is mainly exploited for firewood, worked under a modified clearfelling system prescribing reservation of the young growth up to 12 inches girth with a rotation of 20 years. In some felling series, *ber* forms about one-fourth of the stock. There is a good market for the grafted variety of *ber* fruit which is famous throughout even the Bombay province. Taking one coupe, *e.g.*, coupe No. 16, of 80 acres (worked during 1944-45), S.F.S., XVIII for the calculation of yield, expenditure, etc., the following is the result:—

Total number of trees in the coupe	3,020
Number of *ber* trees in the coupe ..	800
	Rs.
Average price of the coupe ..	650 (being the last 3 years' average)

Likely expenditure on grafting and tending :—

	Rs.
Cost of grafting including the replacing of casualties at As. 4 per tree	200
Cost of tending and protecting during the first year at As. 2 per tree	100
Total ..	300

With an initial expenditure of Rs. 300 on grafting, the yield is likely to be realised from the second year of its grafting. The right of collection of *ber* fruit should be farmed out to contractors every year.

The royalty likely to be realised is, at As. 8 per tree, Rs. 400; (the average yield per tree being at least half a *maund*).

The amount of Rs. 400 will be the additional revenue per year up to the 20th year when the coupe will come under clearfelling. If it is considered, then, that the grafted trees are not likely to give a sustained yield for the next rotation the trees can be pollarded above the grafting point.

It is not suggested here that other means of regeneration of the area either artificial or natural should be totally abandoned. All efforts for natural regeneration or artificial regeneration should be made, as would have been the case in the absence of the introduction of grafting of the *ber* trees. The introduction of grafting fruit trees should be taken as a supplementary means to increase the revenue and not as substitute for artificial regeneration of other suitable species of the tract. It is not contended that the forests should be turned into gardens and thus be only misnomers in such areas. The possibility of introduction of grafting fruit trees well deserves attention to increase the revenue of minor forest produce.

LAND IMPROVEMENT IN THE PROVINCE OF BOMBAY*

By V.A.N. Sausman, M.B.E., B.F.S.

(*Land Improvement Officer, Southern Circle, Bijapur*).

The old works of metal breaking etc. which have proved successful as famine relief measures in areas occasionally subject to famine and scarcity, were recognised to be of little value to a district like Bijapur where famine or scarcity is the rule rather than exception. In consequence, the famine of 1942-43, following as it did on two years of great scarcity, called for some measures of relief less harsh and wasteful than metal breaking. Further, something was urgently needed in the nature of a cure or rather preventive than a palliative and, as the Bombay government had already planned for the large scale use of returned troops on land improvement works, it was decided to utilise the labour, which the famine provided to make a beginning on those works.

The general nature of the country surrounding Bijapur reveals an amazingly open treeless tract, except for a few clusters here and there, at low-lying pockets, where soil has accumulated to a depth. Generally, the land features indicate gently undulating form, the prominences on the catchment forming waste lands surrounding the fields below.

The parent rock is basalt which has undergone a high state of disintegration, yet appears to have yielded proportionately less soil which is indicative of a high velocity of forces denuding the tract. The soil types vary from clayey black cotton in fields to hard *murum* on the hill tops, intermittently exposing rounded outlayers of trap strata through different shades of softer *murum* variety at the lower slopes of catchments.

The tract is particularly liable to sheet and gully erosion, hitherto unchecked by any physical means on a wide scale, except for some cross bunds erected across the wider *nalla* beds to arrest soil for local cultivation purposes. Interception by *nallas,* carrying the run-off through the district's main watercourses, the Bhima in the north, the Don running right across the northern part of the district, and the Krishna passing through the heart of the district, ultimately to pour it out into the Bay of Bengal, has been the regular feature, indicating a high proportion of soil loss year after year, tending to impoverish a one time flourishing tract. The general causes of this extensive state of erosion could be sought in:—

1. The temperature range through seasons varying between 70° in winter and as much as 108° in summer.
2. Sudden outburst of rain often washing away the top soil.
3. The exposed conditions of tract due to lack of tree growth promoting desiccation.

*Paper presented at the 6th Silvicultural Conference, Dehra Dun (1945), communicated by the Silviculturist, Bombay, on item 6—*The Afforestation of Dry and Desert Areas.*

4. Uncontrolled state of grazing reducing soil fertility.
5. High wind velocity of strong, westerly breezes during the hot season estimated to reach a speed of 60 miles per hour causing wind erosion.

In recent years the average rainfall appears to have dropped from 22 inches to 18 inches but as averages are mere mathematical calculations meaning nothing, the incidence of precipitation is of greatest urgency to this famine tract. It is not uncommon to have this rainfall in just three or four showers and the precipitation of 6 inches in 24 hours is to be expected. The peculiarity of the rainfall however is that about a quarter of the annual rainfall falls during the period of the south-west monsoon and the remainder in a month immediately after and coinciding with the burst of the north-east monsoon. Another characteristic is a couple of precipitations in April-May and another couple in mid-winter.

These heavy and irregular precipitations have led to the questions of soil and water conservation, because without these crops are irregular. But of the total acreage of the land in Bijapur district, a fair proportion is under forestry. Here too this area under forestry is confined to that part of Bijapur district south of the Krishna river and which is comparatively more hilly than the portion to the north. Of the remainder of the land, 31 lakh acres are under cultivation and the rest just barren waste producing no vegetation worth talking about. Of these 31 lakh acres under cultivation, 70 per cent. are the rich *rabi* crop soils, chiefly the black cotton soil, and the rest *murumi* soil suitable for *kharif* crops. The areas most exposed to erosion are those served by the heavy rain in the month following the cessation of the south-west monsoon. These are the *rabi* lands, because the *kharif* lands are covered by crops. In this way the richest soil of Bijapur district is being wasted.

The broad principles of soil and moisture conservation are the same throughout the world but the factors of the locality decide the treatment for any given area. All lands under cultivation and likely to be brought under cultivation within 10 years are treated for bunding, whereas waste lands not lilkely to be brought under cultivation within 10 years are treated by trenching. The intermediate stage, *e.g.*, when there is a doubt whether a land can or cannot be brought under cultivation in 10 years' time always works in favour of the land-owner and every third trench is made into a bund, but for its immediate treatment in all other respects it is treated as a trenched land.

In Bijapur district, the areas covered so far under land improvement are private lands and, in consequence, it is not common to find these three broad divisions of land, according to working classes, intermixing with each other. This private ownership is a matter of some advantage for working, because, it immediately does away with the necessity for eradicating or curtailing rights and privileges which are ordinarily met with on government areas and as all benefits accruing from the work goes to the land-owner, he has not been slow to appreciate the fact and render us all possible assistance necessary in the matter of closure, etc.

It is not my purpose to deal here with bunded areas and I shall, in consequence, confine myself entirely to trenched lands only. The main objects sought by trenching are:—

(1) To impound the water and the silt and thus assist the water to saturate into the soil.

(2) To improve the soil quality by utilizing the impounded water to weather the subsoil.

(3) To raise the subsoil water level in the surrounding country.

(4) To improve pasture.

(5) To increase the area under cultivation by the provision of subsoil water and the formation of subsoil soil.

(6) To meet the domestic needs for small timber and fuel.

(7) To create windbreaks.

(8) Generally to improve soil and moisture in the catchment area in which these trenches fall.

In order to attain these objects as rapidly as possible, it was essential to launch out on as large a scale as possible, and, in the first year of working alone, about 34,000 acres of land were brought under trenching, forming together with the lands bunded, an almost continuous line of improved work of 40 miles extent. The works were started at 8 miles apart with a view to joining them up and forming a compact

mass as early as possible, because it was realised that the water which had saturated would many more times have a beneficial effect in an accumulated state than it would have if it formed some numerous disjointed units.

It was believed, utilizing the knowledge with the little rainfall which naturally saturates in and feeds the wells for a year, with all the water put in over a very large area, that the passage through the soil would be effective, at least, for the year to irrigate forest growth sown in these tracts. Though the trench digging was not commenced until the south-west monsoon had well advanced and the correct period for seed sowing had been thereby lost. We were able to sow up between three and four thousand acres of trenched lands during the 1943 monsoon and the remainder were sown up during the 1944 monsoon. In the 1943 season, seed sowing was even done during the month's rain in September-October, 1943, and much of that seed lay dormant till the unseasonable 3-days rainfall of March, 1944, when it began to sprout. Apart from this unseasonble rain in March, 1944, the precipitations usually expected in winter and April-May 1944, did not materialize ; withal, not only did germination of the last monsoon but also of March ,1944, thrive through the summer but the mortality percentage is under 10 per cent. This has been the most interesting factor and has proved the passage of water high up in the subsoil enabling the plants to live throughout a summer which was hotter and longer than usual this year, because our rains did not come this year till July. Even in the 30 odd thousand acres covering a total approximately of 18 lakhs of running feet of trenches planted up this year, the germination percentage has been very high and the area is well stocked.

We were favoured with visits to the forest area by H. E. the Viceroy, H. E. the Governor of Bombay, the Bengal Famine Commission, Sir Herbert Howard, Inspector-General of Forests to the Government of India, Lt.-Gen. Hotten, and other high ranking officers throughout India and I leave it to Sir Herbert to express his opinion at the meeting of the silvicultural conference on the work. But to assist him I am now giving a few facts as regards the maximum and average height growth obtained by the forest species in a period of about 15 months.

	Name of species.		*Maximum height.*		*Average height.*	
			Ft.	Ins.	Ft.	Ins.
1.	*Cassia siamea*	..	10	8	5	0
2.	*Hardwickia binnata*	..	6	0	3	6
3.	*Azadirachta indica*	..	7	6	5	0
4.	*Tamarindus indica*	..	3	0	2	0
5.	*Anacardium occidentale*	..	3	4	2	6
6.	*Butea frondosa*	..	2	8	1	8
7.	*Ougenia dalbergiodes*	..	3	0	2	0

This high growth has been attained in spite of the fact that during each of the two monsoon seasons, a period of drought almost of two months' duration prevailed. A further disadvantage is that for the four months from May annually (and the two monsoon seasons under report were no exceptions) high winds attaining an average velocity of about 22 miles per hour per day and often reaching 60 miles per hour for short periods prevailed tending to dry off moisture thereby intensifying the droughts and give the tree such a battering that damage to root system must be expected. In consequence, when these winds cease and the one-month heavy rain period arrives, the plants are busy recuperating from the battering rather than developing. This must be true, at least for the areas brought under forestry early in the work, for they will be the wind-breaks for which we aim and their part in moisture conservation by increasing the humidity in their localities cannot be too greatly emphasised.

In order to test these theories, trenches were dug immediately behind bunds in these barren lands and they were also sown up. With the bunds on their upper toe, the only moisture available to the plants in the trench was that through saturation and a striking feature is that the growth both quantitative and qualitative is almost on a par with that on the bund.

Although the work has only been in operation for one full season, certain immediate effects have become visible. They are (*a*) the better stand of grass between trenches. In fact grass cutting in some areas has been undertaken for the first time in living knowledge in these areas, (*b*) areas never known to be brought under plough have been brought under cultivation—not very successfully—for the first time and (*c*) the usual Irish bridges which are a source of annoyance after a heavy downpour have more or less been dried since the work began.

For an average rainfall of 20 inches it was deemed advisable to space the trenches, which are strictly on the contours 70 feet horizontally apart at the starting point (bench-mark). As I said earlier, the factors of the locality have to determine details and it was found that the factors of the locality in Bijapur were such as called for an early and immediate revision in the spacing inasmuch as the rainfall received during the south-west monsoon is only a very small fraction of that received during the year. It was realised that if the plants were surviving at the period of one month heavy rainfall coinciding with the burst of the north-east monsoon, then establishment was assured. The spacing of 70 feet horizontal distance between two trenches did not give a sufficient accumulation of water in a trench to help the young seedlings to tide over the two-month period of drought and aggravated by the strong winds which come early in their life and, so, the spacing was increased to 150 ft. horizontal distance apart. This spacing for a trench with a section of 2×1 feet was tantamount to a pro-erosion rather than an anti-erosion measure; because the accumulation was so heavy that the surplus rushed away downhill. This brought in a further consideration of work and in consequence, long continuous trenches were abolished for ones 200 ft. in length with an untrenched space of 3 ft., length followed by another trench of 200 ft. The patch of this untrenched portion was to act as a safety valve over which any extra water for a given precipitation spills over. It further ensured that the young seedling, which was sown at this ground level, would never be over-topped and killed out by stagnant water. At the same time, it permitted the maximum amount of saturation for that seedling at the point needed most, that is, at its root system, and this pro-erosion method of work itself, in the matter of a few years with the establishment of the grass and forest stand, becomes in fact an anti-erosion method of first importance. I doubt if the grass and forest stand could, in the conditions prevailing in Bijapur district, be obtained under any other method.

Finally, the facts herein given cover work already done and horizontal distances, etc. will have to be and must be considered as the work advances into areas more undulating than they are at present, because, as the work proceeds in steeper country, the runoff will be quicker and the horizontal distances must, in consequence, be reduced.

HEDYCHIUM CORONARIUM AS A SOURCE OF PAPER

By S. N. Dabral

(*Silviculture Ranger, Forest Research Institute, Dehra Dun*)

Some years ago it was suggested that *Hedychium coronarium*, commonly called the "Indian garland flower" might be a possible source for paper. In consequence a small plantation of it was raised by the silviculture branch and tests carried out by the utilisation branch of the forest research institute, Dehra Dun.

References to literature showed it to be a stout, hardy, handsome, leafy, rhizomatous herb, growing to a height of 3 to 4 feet with white showy flowers. It is common all over the country but nowhere abundant or gregarious. Its usual habitat is along water-courses. The plant is also said to exist to a certain degree with *bhaber* grass. The Curator, Government Botanic Gardens, Ootacamund, ' states that in Madras it appears to do best in higher elevations of 4,000 to 7,000 feet in damp places. It is found in Ranchi and Palamau at over 2,000 feet, and in Mayurbhanj at over 3,000 feet. It is also said to be common in the west savanahs of Jalpaiguri district.

Through the forest botanist 21 rhizomes were obtained from the Curator, Government Botanic Garden, Ootacamund, Madras, and these were our original stock. They were planted at the end of August 1941, in the experimental garden of the forest research institute in fairly hard soil at the western side of a *Casuarina* plantation. In 1942, 216 rhizomes were dug up and the plantation extended, part of it being put under the shade of the *Casuarina* plantation.

Sprouting commenced after a few days and within a fortnight all rhizomes had produced new shoots. During the following month frequent irrigations were given until the plants appeared to have become completely established. (It must be emphasised here that

we had no experience of growing the plant and knew nothing about it except that it liked water courses and damp places.)

The total irrigation given during the different months together with the average monthly rainfall during the last four years is given in the following table in inches. Each irrigation was of 2-inch delta.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1941													
Irrigation ..	..	..	..	..	..	..	..	..	3	1	1	1	6
Rainfall ..	..	..	..	..	..	..	..	..	6.70	2.67	0.84	0.39	..
1942													
Irrigation ..	1	1	2	2	..	1	..	..	..	..	r	r	7
Rainfall ..	3.14	5.49	0.56	1.22	3.04	8.66	26.83	41.02	11.76	..	..	2.28	105.0
1943													
Irrigation ..	..	..	3	1	4	1	..	..	..	1	3	1	14
Rainfall ..	3.66	1.25	1.04	1.99	1.35	4.23	24.81	52.02	19.69	..	..	..	110.04
1944													
Irrigation ..	1	..	..	1	1	r	..	..	..	..	..	..	3
Rainfall ..	3.25	2.17	5.99	2.62	0.03	4.43	29.62	19.48	4.51	0.89	..	0.07	73.06
Average during these months — Irrigation	1	1	2	1	2	1	..	..	1	1	1	1	..
Average during these months — Rainfall	3.68	2.97	2.53	1.94	1.47	5.77	27.09	37.51	10.67	0.89	0.21	0.69	..

Under the above conditions of rainfall and irrigation the plant grows very fast and does extremely well. On the average March and May require more than one irrigation otherwise one irrigation a month is quite sufficient to prevent the drying of the plants.

The plant grows very rapidly from rhizomes and takes root very easily provided there is sufficient watering at the start. The growth of the plant is like that of its allied species, ginger and turmeric. It sends out shoots from a clump, but the propagation is rather more lateral than circular. Some of the plants have been noticed to produce rhizomes in a straight line of more than 2 feet in length. The rhizomes of the previous year if left in the ground generally shoot with the advent of summer showers and grow vigorously in warm and moist weather.

Phenology.—The yellowing of leaves begins to take place just after the flowering which commences about the middle of September. Growth then declines with the leaves yellowing and the rhizomes resting. Plants are in full flower during the first half of October after which they commence to fade. The end of the flowering takes place in the beginning of November when the crop becomes ready for harvesting. The stems become quite stiff and the leaves appear yellow and begin to drop down. The dying back of the old shoot and leaves is, however, much slower than in its allied species, turmeric and ginger, as it is a perennial resident of damp places.

Preparation of the stock for paper.—The leaves are taken off by hand and the stems are kept in the sun for drying. The period taken for complete drying in the winter sun of Dehra Dun is about 24 days excluding cloudy and rainy days.

Yield.—Our plantation was only very small and in consequence only gives us a very approximate idea indeed of possible yields. The average number of stems per clump was 15 for a plantation 13 months old, the minimum and maximum heights being $3\frac{1}{2}$ feet and 6 feet respectively with an average height of $4\frac{1}{2}$ feet. These stems were produced from rhizomes 2 to 3 inches long. The weight of each green stem with leaves was 10 ozs. and without leaves 7 ozs.

Our small plantation showed a yield of approximately $1\frac{1}{2}$ tons of dry material per acre and this yield was roughly 50 per cent.

greater in the shade of *Casuarina* than in the open (*i.e.*, about $2\frac{1}{4}$ tons per acre).

Each year the material was sent to the utilisation branch who gave us the following note :—

"Laboratory experiments carried out on *Hedychium coronarium* have given very promising results. The material appears to be very suitable for the manufacture of paper.

It yielded 52·4 per cent. paper on the air-dry weight of the material. Paper made from this material possessed remarkably high resistance to folding (1,133 double folds) and breaking length (9,770 metres).

There is a *prima facie* case for carrying out large scale tests on *Hedychium coronarium* in our experimental paper making plant. The minimum quantity of air-dry material required for these tests would be 2 to 3 tons. Before undertaking the tests we would, however, like to know if plantations of *Hedychium coronarium* could be raised in any part of India to give a sustained annual output of at least 15,000 tons, and if so, what would be the approximate cost per ton of the material thus raised."

Conclusion.—We have thus shown that *Hedychium coronarium* is comparatively easy to grow and small scale experiments have shown that it is an excellent material for paper. It now remains to be seen whether any province or state is sufficiently interested to follow them up by producing enough material for large scale tests.

AFFORESTATION OF DRY AND DESERT AREAS WITH A RAINFALL OF BELOW 30 INCHES IN THE UNITED PROVINCES*

By K. D. Joshi, I.F.S.

(Divisional Forest Officer, Afforestation Division, U.P.).

FOREWORD.—Such tracts are not comprised by the main forest belt of the United Provinces and the only areas falling into this category are the ravine blocks of Etawah, together with a few forest blocks in other western districts. Extensive afforestation operations were carried out between 1914 and 1929 after which (as a result of our experience) the afforestation policy was changed to the present one of restocking such areas by natural means, induced by protection combined with regulation of grazing.

The following note by the Divisional Forest Officer, Afforestation Division, U.P., summarizes the work done and position to date.

E. W. RAYNOR,
Conservator of Forests,
Working Plans Circle, U.P.

Introduction

The credit for inaugurating an afforestation policy in the United Provinces is due to Sir John Hewett (late Lieutenant-Governor of the United Provinces) when in 1912, he enunciated a clear-cut policy of government in regard to the afforestation of the denuded areas and the establishment of fuel and fodder reserves throughout the province. The outstanding pioneers of this afforestation policy were Sir P. H. Clutterbuck (late Inspector-General of Forests), Mr. Neil, I.C.S., and Messrs. Courthope and Benskin of the forest department. The main work of afforestation was confined to the Etawah district where extensive ravine areas stood denuded along the banks of the Jumna

*Paper presented at the 6th Silvicultural Conference, Dehra Dun (1945), on item 6—*The Afforestation of Dry and Desert Areas*—communicated by the Conservator of Forests, Working Plans Circle, United Provinces.

and the Chambal rivers. The aims then envisaged were :

(*i*) Ravine reclamation to prevent further erosion ;

(*ii*) creation of fuel and fodder reserves for local villages ; and,

(*iii*) a financial scheme for obtaining a profitable return from these waste lands.

A number of areas intended to form nuclei for further extension were taken up along the Jumna and Chambal ravines in Etawah district, together with a few other areas in Agra, Aligarh, Cawnpore, Unao, Jalaun and Lucknow districts. The afforestation programme came into full force from 1914, when the areas were brought under definite schemes. This continued until about 1929 when it was found by experience that some of the schemes, *e.g.*, of growing large-sized timber species for the sake of financial outturn, were unduly optimistic and unsuitable, since such trees could not be grown immediately without first reclaiming the land and creating a good layer of fertile soil fit to bear a better type of tree growth. Due to the existence of a *kankar* (*Calcareous nodules*) pan beneath, all deep-rooted species such as *sissoo* (*Dalbergia sissoo*) and *babul* (*Acacia arabica*), which were tried initially on an extensive scale, were found dying out after about 10 years when their roots were arrested by this impenetrable layer. Deeper pockets of soil in depressions were, however, found more favourable for tree growth. These observations were later confirmed and led to an abandonment of the tree-growing policy over the whole of the denuded areas.

The policy thus changed to one of protecting such areas as fuel and fodder reserves by encouraging indigenous fodder grasses together with the few indigenous fuel species such as *reonj* (*Acacia leucophloea*) and *cheonkar* (*Prosopis spicigera*) in order to augment fodder and fuel supplies to local villages. Regular schemes of periodic and rotational grazing regulation were then introduced to improve the grazing and supplies of fodder for the large herds of cattle owned by the villagers. This is now the present policy and no further propagation of tree species is now undertaken.

Area.—The afforestation work attempted from 1914 to 1929 covered the following areas :

In Etawah District, out of 18,874 acres available, 9,000 acres were planted.

In Agra District, out of 2,431 acres available, 2,431 acres were planted.

In Aligarh District, out of 628 acres available, 628 acres were planted.

In Cawnpore District, out of 408 acres available, 408 acres were planted.

In Unao District, out of 90 acres available, 90 acres were planted.

In Jalaun District, out of 3,900 acres available, 3,900 acres were planted.

In Lucknow District, out of 279 acres available, 279 acres were planted.

Objects of treatment.—In treating the ravines, the primary objects were—

(*i*) checking further erosion ;
(*ii*) improving soil aeration and moisture content.

There is no doubt that to a great extent, the work done in the period up to date has achieved the first object while the second is a slow process and will take years to achieve.

Bunding.—Before starting work, it was considered essential to check erosion by systematic *bunding* or plugging of the existing ravines. This was done by starting bunding at the tops of the side ravines and proceeding downwards to the junction of the main ravines. Water escapes were judiciously constructed for taking off flood water without destroying the main bunds. On the upper side of these bunds where a pool of water collected in the rains, appreciable silting occurred and in a year or two a level deposit of rich soil was obtained.

The method adopted for afforestation during the period 1914—1929 is described below :—

(*a*) **Soil Preparation**

(*i*) *Preparation of flat high-level land.*—The whole surface was ploughed up with English

Sabul ploughs to a depth of 9 or 10 inches and the crust was thoroughly broken up. Small parallel ridges (1 ft. high and 2 ft. broad at base) 10 ft. apart were made by paid labour, usually with a shallow ditch on the upper side to catch rain water. The same method of preparation was employed in ravine land also, wherever the ground was flat or gently sloping.

(*ii*) *Preparation of steep slopes in the ravines.*—Vertical slopes were left untouched but all slopes up to 60° were treated by preparing shallow platforms or ditches and ridges contour-wise. The ditches acted as silt and water traps and the ridges as efficient seed-beds. Petty irregularities in the surface were at the same time eased off as far as possible, pinnacles of earth knocked down, knife-edge ridges flattened, runnels (eroded by rivulets) were smoothed off and so on.

(*b*) Sowing and Weeding

Soil preparation was completed in the month of May and in June when the rains started, *babul, sissoo* and other seeds were sown on the ridges, *babul* and *Cassia auriculata* on the steep slopes and on the worse and drier areas, while more valuable species mixed with *babul* (which acted as a nurse and as a safeguard against grazing) in all the better areas, *babul* being avoided in the hollows where frost was likely. The species sown were :—

Babul, sissoo, Cassia auriculata, teak,*Gmelina, tun* (*Cedrela toona*), *haldu* (*Adina cordifolia*), *kanju* (*Holoptelea integrifolia*), *reonj, cheonkar, Harawickia binata, Bombax, sal* (*Shorea robusta*), *Acacia jacaranda, Acacia sumaete.*

First weedings were carried out about a fortnight or 3 weeks after germination. In the second half of August, second weedings combined with loosening of the soil were carried out. A third weeding was done by the end of September, accompanied by a final loosening of the soil.

(*c*) Subsequent Tending

In the second year, backward and defective areas received soil-working between the lines, the surface being loosened by ploughing or digging. The young plants were also weeded and thinned out to 4 ft. spacing. Grazing was stopped until the fourth year, especially for the *sissoo* plants. The species most susceptible to grazing were found to be *sissoo, tun, haldu* and *Gmelina*. After the second rains, or sometimes in the first cold weather, the first thinning was carried out, the young plants being left from 3 ft. to 4 ft. apart. Later, thinnings were regularly done in the first year (termed "spacing of plants"), in the 3rd year, in the 6th year and in the 9th year.

(*d*) Results

Growth of tree species.—On ridges with ditches in June 1915 (ridges 10 ft. apart), the plants of 4 years of age in 1919 showed a maximum height of 20 ft., an average height of 18 feet, a maximum girth of 1 ft. 3 inches, and an average girth of 9 inches, with 74 stems per acre.

On low-lying flat sandy loam in the bottom of a large ravine the growth observed in 1919, $2\frac{3}{4}$ years after first germination showed a maximum height of 19 ft., an average height of 15 feet, a maximum girth of $8\frac{1}{2}$ inches and average girth of $6\frac{1}{2}$ inches, with 1,100 stems per acre.

Improvement of fodder grasses.—The effects of the intensive soil-working and protection were almost immediately noticeable in the improvement of the fodder grasses. Common and worthless grasses gave place to valuable fodder grasses. Regulation of grazing was rightly considered as the main basis for improvement of grasses in these tracts by means of which, it was hoped to afford considable relief to the cattle which roam about in a semi-famished condition in the winter and summer months.

General

It was rightly emphasized that in the reforestation of ravine lands, the financial aspect was not the only criterion of the success or failure of the venture. The arrest of erosion and the creation of fuel and fodder reserves for local villages were of equal or greater importance.

COSTS OF CREATION AND UPKEEP OF RAVINE PLANTATIONS.

Details	On flat lands without bunds per acre (*a*)	On moderate ravine lands with bunds per acre (*b*)	Remarks
	Rs. A. P.	Rs. A. P.	
Soil preparation ..	10 0 0	25 0 0	Total initial cost per acre : 1. On flat ground Rs. 8. 2. On ravine land Rs. 33.
Sowing, tending and protection for 1st year ..	8 0 0	8 0 0	
Subsequent tending and beating up failures ..	0 8 0 (per annum)	0 8 0 (per annum)	Total recurring expenditure : Rs. 1/8/- per annum.
Miscellaneous recurring expenditure (roads, tools etc.)	0 8 0 (per annum)	0 8 0 (per annum)	
Staff ..	0 8 0 (per annum)	0 8 0 (per annum)	Total recurring expenditure: Rs. 1/8/- per acre.
TOTAL .. (creation) (maintenance) ..	18 0 0 plus 1 8 0 (per annum)	33 0 0 plus 1 8 0 (per annum	Note :— The budget allotment for 1920 in the afforestation division for 1,600 acres was Rs. 44,000, or Rs. 27/8/- per acre.

These figure which were prevailing at the time when the afforestation work was in full swing, are now obsolete.

Revenue, Expenditure and Surplus

The area thus afforested amounted to over 26,000 acres. The average revenue per year at present is Rs. 25,171 or about As. 15 per acre. The expenditures Rs. 38,555 or Re. 1/7/- per acre, resulting in a net deficit of As. 8 per acre.

STATEMENT OF WILD ANIMALS SHOT IN SOME OF THE INDIAN

All India Serial Number	Species	Ajmer-Merwara	Assam	Bengal	Bihar
1*a*	Tiger	..	74	28	4
1*b*	Tigress	..	5	11	1
2	Leopard or panther	..	23	31	3
3	Wild cats (species to be given if known)..	..	3	10	1
4	Lynx	..	..	..	..
5	Hunting leopard or cheetah	..	2	..	..
6	Hyena	..	..	..	2
7	Wolf	..	..	..	..
8	Wild dog	..	61	1	..
9	Martens	..	..	1	..
10	Ratel	..	..	..	..
11	Brown bear	..	1	..	..
12	Himalayan black bear	..	..	6	..
13	Malayan bear	..	..	..	..
14	Sloth bear	..	1	..	3
15	Wild elephant	..	53	20	..
16	Rhinoceros (species to be given) ..	..	5 (*R. unicornis*)	..	..
17	Gaur or bison	..	3	..	2
18	Goyal or mithan	..	..	..	..
19	Banting or tsine	..	..	..	..
20	Wild buffalo	..	5	..	..
21	Urial or sharpu	..	..	..	..
22	Bharal or blue sheep	..	..	..	..
23	Ibex	..	..	..	..
24	Markhor	..	..	..	..
25	Tahr	..	..	..	..
26	Nilgiri wild goat or Nilgiri Ibex ..	..	..	..	..
27	Serow or Himalayan goat antelope ..	..	..	3	..
28	Goral	..	..	6	..
29	Nilgai or blue bull	..	..	..	1
30	Four-horned antelope	..	..	..	..
31	Black buck	..	..	..	..
32	Indian gazelle or chinkara	..	..	..	..
33	Barking deer or kakar	..	156	226	5
34	Kashmir deer or hangul	..	..	..	..
35	Swamp deer or gond or barasingha ..	..	..	..	..
36	Brow-antlered deer or thamin ..	..	..	..	..
37	Sambar	..	14	53	21
38	Cheetal or spotted deer or axis deer ..	..	..	634	13
39	Hog deer or para	..	58	33	..
40	Musk-deer	..	..	..	..
41	Mouse-deer	..	1	..	..
42	Pangolin	..	..	..	..
43	Crocodile (muggar)	..	..	5	..
44	Gharial	..	..	..	..
45	Python	..	1	1	..
46	Others (species to be given)	7 (pigs)	69 (pigs)	350 (pigs 323 hare 27)	9 (pigs 7 jackals 2)

PROVINCES AND STATES DURING 1944-45

Bombay	C.P. and Berar	Coorg	Madras	Orissa	Punjab	Sind	U.P.	Jammu & Kashmir State
10	34	6	Information not available.	4	..	..	53	..
5	17	..		..	..	..	29	..
28	46	19		3	25	..	61	..
..	..	12		..	2	..	29	108
..	..	..		..	..	..	..	1
..	..	..		..	..	..	..	3
..	4	..		..	..	..	16	..
..	2	..		..	1	..	..	..
1	6	1		2	1	..	6	..
..	..	..		..	..	..	2	4
..	..	..		..	..	..	..	..
2	..	..		2	3	..	..	..
..	..	..		..	12	..	5	14
..	..	..		..	..	..	..	..
2	17	..		..	..	..	18	..
9	..	1		1	..	..	..	..
..	..	..		..	..	..	..	..
8	3	6		3	..	..	..	..
..	..	..			..	..	..	..
..	..	..		..	..	..	..	..
..	..	..		..	..	..	..	..
..	..	..		..	18	..	..	2
..	..	..		..	1	..	..	..
..	..	..		..	..	..	..	5
..	..	..		..	..	..	..	1
..	..	..		..	..	..	..	..
..	..	..		..	..	..	..	..
..	..	..		..	1	..	1	..
..	..	..		..	30	..	21	..
13	69	..		..	15	..	86	..
..	1	..		..	..	2	1	..
..	2	..		..	..	..	4	..
..	22	..		..	..	..	5	..
..	44	6		6	29	..	41	..
..	..	..		..	..	..	..	2
..	1	..		..	..	..	24	..
..	..	..		..	..	..	..	..
9	64	2		8	..	..	84	..
8	117	16		4	..	..	181	..
..	..	..		..	..	1	14	..
..	..	..		..	4	..	..	..
..	..	..		..	..	..	..	..
..	..	..		..	..	..	..	..
..	..	..		..	..	..	6	..
..	..	..		..	..	..	..	..
..	..	..		..	..	..	1	..
1,370 (pigs)	228 (wild pigs 225 and other deer 3)	17 (pigs)		3 (pigs)	99 (pigs 44 jackals 5, porcupines 6, hare 28, fox 2, martin 4, wild boars 10)	82 (pigs)	1,020	191 (jacklas 135, fox 53, otter 3).

108TH ANNUAL REPORT OF THE DEPARTMENT OF LANDS AND MINES, NEW BRUNSWICK (CANADA) FOR THE YEAR ENDED 31ST OCTOBER, 1944, 125 PAGES

Revenue for 1944 was larger than the average for the decade 1930—39 by about 75 per cent.

Losses and damage caused by fires in 1944, however, were greater than in any year since 1923. More than 289 sq. miles were burnt out. 85 per cent. of the damage was caused by fires attributed to lightning.

Among the lessons learnt, it was evident in many cases that to be able to combat fires successfully a system of motor truck roads with good telephone or radio communication is vitally important and that until such facilities are available adequate protection cannot be given to forested areas outside those served by the secondary road system.

Fires are designated by classes as follows:

Class		*Description*
A	..	Less than $\frac{1}{4}$ acre
B	..	$\frac{1}{4}$ to 1 acre
C	..	1 to 5 acres
D	..	5 to 10 acres
E	..	10 to 50 acres
F	..	50 to 100 acres
G	..	100 to 500 acres
H	..	500 acres and over

Arrangements were made with the dominions to have a complete aerial survey. Photography was begun in 1944 and will be completed in 1945. The photographs are verticals, taken from a height of about 1,200 feet above sea level and will be to a scale of about 4 inches to one mile. These phorgraphs supply the essentials for a programme of organised development.

J. P.

EXTRACTS

SOIL EROSION IN BALUCHISTAN*

BY SIR HAROLD GLOVER, B.A., I.F.S.

(*Late Chief Conservator of Forests, Punjab*).

INTRODUCTION

Throughout Baluchistan the soil is being heavily eroded, and in 1944, at the request of the Honourable the Chief Commissioner and Agent of the Governor-General, I toured throughout the province and submitted a report on soil erosion and on forest conservancy.

Soil erosion is very widespread and all classes of land are seriously affected. The forests are retrogressing, the productivity of the pastures has been lowered through the erosion of the surface soil, following on the destruction of the vegetation by overgrazing. The cultivation is threatened, and sudden and destructive floods rush down the *nullahs* after every considerable storm of rain. The economic balance has been upset and man and his animals are living at disharmony with their surroundings.

*It is regretted that the twelve plates which illustrated this article could not be reproduced.—*Ed.*

The cure is the control of grazing; the restoration and protection of the vegetation of the pastures and the forest; better methods of cultivation. The flocks of sheep and goats must be limited to the numbers that the vegetation can support.

It is easy to devise remedies, but it is very difficult to put them into practice. The people themselves must be persuaded that the remedies suggested are practical and there must not be too great disturbance in their lives.

Situation and Physical Characteristics

Baluchistan is an eastern continuation of the Persian plateau and lies between Persia and the valley of the Indus. The country is mountainous with high upland valleys which form long stretches of flat or gently sloping land walled in by barren-looking hills.

The formation of these upland villages is due to the low rainfall, which is insufficient to carry away detritus. Conditions are changing slowly, as owing to disforestation and to the reduction of the already scanty vegetation by heavy grazing, the rate of run-off of storm water is now greater than it was when the upland valleys were formed. There is sheet erosion on all hill sides and there are wide stretches of naked sheet rock; where the underlying rock of the hills consists of clays or detritus there is gully erosion; on the upland valleys sheet erosion is universal. On the edges of the main drainage channels ravines are extending into the plateau, particularly in the Quetta-Pishin district. The beds of the streams are dry and stony except after a fall of rain when the torrents descend their stream beds in the hills with great violence, and, when they reach the plains, spread out in fans and form numerous channels, behaving in a manner similar to that of torrents in regions of greater rainfall.

Climate

The climate of Baluchistan is one of extremes with severe cold in the winter at high elevations and intense heat in the summer at the lower elevations, particularly in the low foothills and the plains, where shade temperatures reach 126° F. At higher elevations the day temperatures are high in the summer, but the nights are always cool. In the winter the climate is cold and snow falls. Long periods of drought and high winds are particularly unfavourable to vegetation.

Rainfall

The rainfall, increasing with elevation and depending on situation, shows marked variations throughout the year. Usually the wettest months are January, February and July, followed by long periods of drought which only occasionally are broken by storms of tropical intensity when much rain falls in a very few hours. At Quetta, elevation 5,500 feet, the annual average is 10 inches. At Dalbandin only 3½ inches.

Economic Background

The rural population is expanding only slowly, if at all, in marked contrast to other parts of India. The people are indolent, do not join the Army, but prefer to take service in local levies, are uneducated and have not advanced greatly in the past 50 years.

The hill tract has a population of only eight persons per square mile, widely distributed in small villages or nomads encampments in upland valleys separated by steep hills. The small numbers of the people and their sporadic distribution make all kinds of administration, inclusive of that of the forests both expensive and difficult. The tribal system is in force and the Maliks or local headmen possess considerable influence over the tribesmen.

Before the British occupation in 1879 little land was cultivated, as life and property were unsafe. Shepherds were able to hide their flocks in the recesses of the hills, and the main business of the country was grazing. With the increasing peace and security of recent years; more people have taken to agriculture, but, partly owing to the dry climate and difficulty of irrigation, there is far more land available than there are men to cultivate it.

There are fine fruit orchards near Quetta and Loralai irrigated by underground water channels, artesian wells or permanent water channels, and there are cantonments at several centres which have created a local demand for firewood, animal and vegetable products and for labour. There are coal mines, which, owing to the low quality of the coal, are not greatly developed, chrome ore and sulphur mines, but the main industry of the country is grazing. This matter of grazing and its effect on the pastures and soil erosion will be referred to again and again in the course of this survey, but no apology is made for

repetition in view of its dominating importance in the rural economy of the province.

Forests

The forests lie mainly in the hills and occupy an area of 1,762 square miles out of a total land surface of 54,000 square miles. Most of the so-called forest is forest only in name, is afforded but nominal protection, and is hardly distinguishable from the surrounding waste. Certain trees have been classed as "reserved" and can be felled only with the permission of the forest officer.

Forest Products

Timber.—The higher-lying forests consist of old and scattered Juniper trees from which Pencil Cedar is produced, but the timber is so knotty and the grain is so twisted that wastage in conversion to pencil slats amounts to 95 per cent., and it is almost certain that after the war the Baluchistan Pencil Cedar will not be able to compete with that imported from Africa. Juniper timber is used, by local agriculturists, mainly in the form of poles for simple huts.

Firewood.—The local villagers get all their fuel from the forest and the village waste, while there is a continually increasing demand for firewood in the few large towns. There is a large cantonment at Quetta, and there are other smaller cantonments where Indian shop-keepers, clerks and officials have settled. These cantonments in normal times draw their fire-wood supplies from outside Baluchistan, but during the war they have made great demands on the countryside. In their neighbourhood most of the trees have disappeared long ago, and even the roots of bushes such as *Artemisia* have been dug up for firewood.

Drugs and Herbs.—Baluchistan produces *Ephedra* of high quality, and in the last seven years sales have greatly increased in volume and in value. Other drug plants such as *Artemisia maritima* grow locally, and there are numerous aromatic herbs which are collected by the villagers and are used in indigenous medicines. Of late years the sale of Juniper berriers for flavouring gin has greatly increased.

Throughout the forest, with few exceptions, grazing is so heavy as to prevent the regene-ration of trees, and results in the destruction of the bushes and very serious erosion of the soil.

Grazing

The main industry of Baluchistan is grazing. Vast herds of sheep and goats are kept in every village. Cows are not numerous, and are kept only where there is cultivation or alluvial flats where there is grass pasture, as near Gumbaz. There are not enough bullocks to plough more land than is now cultivated. Camels are often used for ploughing, as they cost less than bullocks to keep and feed largely on the camel thorn (*Alhagi camelorum*), which is a common weed in the waste; fewer and poorer riding horses are produced than in former years. In addition to local animals, there are annual immigrations of large flocks of sheep and goats and herds of camels from Afghanistan, and to British Baluchistan from the Marri tribal country. These animals probably do as much or more harm to the pastures than do the local flocks. That the animals have increased greatly, at least by 100 per cent. since the British occupation, admits of no manner of doubt.

In spite of its importance, the grazing industry has received but little attention until recently when a beginning was made with the estab-lishment of experimental sheep farms. No attention whatever has been paid to the proper management of the pastures, which are grazed to far beyond their capacity, particularly by nomadic flocks from Afghanistan, which pay taxes to the Baluchistan Government.

The vegetation of the pastures has every-where received a setback owing to the increased numbers of animals which graze thereon, and no longer is there sufficient fodder to support the present number of animals. Control must be exercised over the movements of both local and migratory flocks and the limitation of their numbers is essential.

The True Function of the Forest

The forest is a complex association of trees, bushes, shrubs, herbs and grasses, all of which supply material for the needs of man and his domestic animals. In addition, the forest protects the soil and enables it to absorb the rain water; not only is protection given to the soil of the forest, but floods are prevented and cultivated fields are protected. The roots of the trees penetrate far into the soil and the crevices of the rocks and bind them together, assisted by the bushes and lesser surface vege-tation. Branches and leaves prevent the

rain in heavy storms from beating down on the surface soil, while the humus formed by the decay of the plants absorbs the rain water and lets it percolate slowly into the soil to emerge later on in the form of springs. Where there is no vegetative covering storm water pours uselessly over the surface of the soil and washes it away; the nullahs come down in spate, the river overflow, and the water, which should have been absorbed by the forest soil and slowly released, is dissipated in destructive floods.

It must not be thought that the value of a forest lies in its trees alone: the ground cover is at least of equal importance, and when the latter is destroyed by grazing, the trees are not able to hold up the storm water. Nature has so provided that the type of forest produced in conditions undisturbed by the acts of man and his animals is everywhere sufficient to prevent the erosion of the soil.

The Effects of the Disappearance of the Forests

Under natural forest, soil accumulates; but when man and his animals have destroyed that forest, Nature takes her revenge. There is no more food for the animals to eat: the soil is carried away in sudden and destructive floods: underground water supplies dry up: fields are swept away and the country becomes uninhabitable. That is not an exaggerated picture of what is happening in Baluchistan as everywhere the vegetation has suffered severely from the very heavy grazing; the soil is naked and has been washed away from steep slopes: soil erosion is already far advanced; every considerable fall of rain is followed by floods (the present year has seen the roads breached in all parts of the Province, dams have been broken and fields have been badly damaged). Unless something is done to restore the vegetation and steps are taken to control the grazing by rotation of pastures, by reduction in the flocks to the capacity of the grazing grounds, and by every means that the mind of man can devise, conditions will become worse and the country will not be able to support its present population. A man-made desert is a dismal future.

Indigenous Forests

There are several main types of natural forest which have survived in especially favoured localities where they have been afforded protection against goats and sheep.

A. Juniper forest

i. *The climax type.*—Situated at from 5,500 to 10,000 feet above sea level, where the annual rainfall varies from 10 to 15 inches, with deep snow in the winter, are some 200 square miles of Juniper (*Juniperus macropoda*) forest, about half of which is demarcated. The trees are very old, are very scattered and are branched to the ground. They send their roots far into the earth, spreading widely and deeply in search of water, and penetrate the interstices in the rocks. This sparsely stocked forest is characteristic of semi-arid conditions. At the highest elevations the trees assume a stunted and prostrate habit and their branches lie along the surface of the ground.

Between the Junipers are slowly-grown dwarf Ash trees (*Fraxinus xanthoxyloides*), wild Almond (*Prunus eburnea*) of bush-like form, wild Cherry (*runus cerasus*), while the ground is covered by a lower storey of bushes of *Caragana gerardiana* and *ambigua*, *Berberis vulgaris*, *Daphne oleoides*, *Ephedra vulgaris*, *Spiraea kabulica*, *Lonicera* and *Budleia*, together with *Artemisia breviolia* and *maritima*, and spiny *Acantholimon* and *Astragalus* perennial plants, thin Khavi (*Cymbopogon jawarancusa*) and other grasses, *Eremurus* lilies, tulips and herbs of numerous cruciferous, leguminous and composite species. As with the trees, so with the bushes, herbs and grasses; the plants are of isolated habit owing to the difficulty with which they are able to obtain sufficient moisture for their growth.

The Juniper is long-lived, occasionally to over 500 years of age, with the result that the old trees persist and occupy far more space than is their due share. Seed is produced copiously and germinates, but the seedlings persist only where conditions are particularly favourable; for example, where the shade of some bush protects the young plants from the intense heat of the sun.

Underneath the old trees, and held up by the support which they afford, soil and humus have accumulated and the *Ephedra* plant finds suitable conditions for growth. The soil in the spaces between the Juniper trees is held in place by the bushes, herbs and grasses.

ii. *The present Juniper reserved forests.*—To-day many old Juniper trees survive, half dead and dying; but their end is not yet, as they take an unconscionable time in dying. Under their shade is still, usually, some earth, but between them the soil is bare and thin,

and only sparsely covered with bushes and herbage. Often the soil is stony, unshaded, hot and dry and on it only xerophytics such as Thyme and *Morina persica* grow. The soil is unable to support the more moisture-loving plants and no longer does the forest produce in profusion the aromatic herbs and shrubs for which Baluchistan was formerly justly famous.

Where the forests are open to grazing the number of animals admitted have not been limited to those recorded as possessing grazing rights. Many of the forests which are open to the exercise of rights are in no better condition than the areas described below.

iii. *The undemarcated Juniper forests.*—Outside the demarcated forests the sole control exercised is over the felling and lopping of Juniper trees, but that is only partially effective. Lopping is nominally controlled, but the trees are lopped for fencing, rafters and fuel. The forests are all heavily over-grazed, the soil has vanished from the bare sheet rock, the roots of old Juniper trees are exposed and everywhere there has been severe erosion of the surface soil. Some *Spirea* and other plants persist in the cracks and crevices of the rocks and a few spiny xerophytic shrubs and grasses manage to survive. Where the soil is deeper, as to the north-west of Ziarat, it is badly eroded. It is too late to perpetuate the old type of Juniper forest, as the soil, where it still persists, is too sterile, but protection from grazing would result in some Juniper regeneration and in the covering of the ground with herbs, grasses and bushes. Demarcation should be extended to the whole of the areas where Juniper is found, and grazing should be regulated as described later on.

B. *The Olive forest* (*Olea cuspidata*)

No natural climax type of Olive forest was seen. Even before the British occupation the forests were heavily grazed and the Olive trees were pollarded, their leaves and branches being a favourite food of the sheep and goats and indeed of all browsing animals. I found no seedlings, but very occasionally saw young Olive saplings amongst dense masses of dwarf palms.

Olive trees persist from about 4,000 to 6,500 feet, or higher. The Olive trees are old, mutilated and are generally mixed with *Pistacio khanjak* or *mutica* trees, most of them are old, and not very occasionally are there a few young *Pistachio* plants. There are a few *Daphne oleoides* bushes, but the main ground cover is grass, which grows in tufts separated one from another by bare earth. The dominant species are *Chrysopogon jawarancusa* and *Eulaliopsis binata*, the *bhabar* grass, which outside Baluchistan is used for ropes and paper manufacture. The soil is far too dry for Olive seedlings to grow.

At lower elevations the Olive is mixed with *Phulai* (*Acacia modesta*) trees, which generally are of poor growth, but which are remarkably persistent and manage to regenerate occasionally under the most adverse circumstances.

At the lowest elevations of all, from about 3,000 to 4,000 feet, there are *Phulai* and some dwarf *Tecoma undulata*, *Zizyphus oxyphylla* trees with *Periploca aphylla*, *Zizyphus nummalaria* and *Ephedra* bushes, with spiny *Acantholimon* bushes and *Sophora griffithii* shrubs, while in steep-sided deep drainage channels in the limestone rocks are numerous old Olive trees which still exist in spite of the heavy grazing. Outside the reserves the forests no longer protect the soil and erosion is very bad indeed.

C. *Spiny shrub and bush type*

From about 3,500 feet downwards the country is very dry, and the natural vegetation consist of xerophytic species such as *Periploca aphylla*, *Karil* (*Capparis aphylla*), *Zizyphus oxyphylla* and *nummularia*, spiny repellent bushes, salsolaceous plants, thin grasses and minute herbs.

D. *The upland valley dry type.*

The beds of the valleys and the lower slopes at about 4,000 to 6,000 feet are covered with *Artemisia brevifolia*, and *maritima* bushes, *Acantholimon* and *Astragalus* bushes, *Sophora griffithii* shrubs and dry types of grasses.

Lower down *Haloxylon*, *Salsola* and other desert plants cover vast stretches of arid flats.

E. *The flood plain type*

In the stream beds on the naked silt appear *Tamarix annulatum* and *dioica* bushes, which obstruct the passage of flood water and cause it to drop its load of silt. These bushes maintain a footing on the stony torrent beds in spite of the heavy grazing, and where they have been protected they sometimes grow well and form dense thickets with much fodder grass (*Cynodon dactylon* and *Dicanthium annu-*

latum). In the glades Oleander bushes are seen, together with *Vitex negundo* bushes and clumps of *Saccharum ciliare* and *spontaneum* grasses. Occasionally there are *Dalbergia sissoo* trees and dwarf palms (*Namorrhops ritchieana*). Where the torrents debouch into the plains and where grazing is heavy *Withania coagulans*, *Rhazya stricta* and *Sophora griffithii* bushes persist.

There is no doubt but that the flood plains of the rivers would be well covered with vegetation if it were not for the exceedingly heavy grazing.

F. *The Chagai desert types*

i. *Stony desert type.*—Extending westwards from Nushki is a stony plateau at about 3,000 feet where the rainfall is about 3 inches and the vegetation consists of scattered bushes which become fewer and fewer until the true desert is reached.

The more common bushes are *Artemisia brevifolia*, *Rhazya stricta*, *Haloxylon griffithii*, *Pycnocycla aucheriana* and *Stocksia brahnica* with a few *Ephedra* and *Periploca aphylla* bushes. There are large clumps of *Pennisetum dichotinum* grass, some *Eleusine flagellifera* grass and minute herbs and grasses.

The bushes are dotted about the plateau as shown in Plate viii.

Heavy rain had fallen, after many months of drought, shortly before my visit and as the vegetation had been browsed there was considerable erosion of the surface soil and the road had been broken in several places.

ii. *The sand desert.*—Near Chandram as one travels towards the west, aridity increases and there are large sand dunes which carry only a very scanty crop of xerophytic bushes. The sand drifts with the north-west wind to form dunes 80 to 200 feet in height which appear to rest on a more fertile clay soil.

The surface of the sand dunes is rippled by the wind and particles are detached from its surface wherever there is no protection from bushes or grasses. The bushes in the valleys, and particularly the dwarf Taghaz tree (*Haloxylon ammodendron*), stand on isolated heaps of soil owing to the effects of wind erosion.

The main species are *Haloxylon ammodendron, alligonum comosum, Astragalus sp., Pycnocycla aucheriana, Salsola arbuscula*. The small grass, *Panicum meliaceum*, which appears after rain only to seed and dry up in a few weeks helps to hold the sand in place, so does the grass *Stipa pennata*. In some sandy areas the grasses *Saccharum ciliare, Eragrostis sp.*, and *Andropogon annalatus* are met with, but they are rare. The Taghaz trees have all been coppiced, with shoots now up to 10 feet in height. They are used for fuel and for making huts. The shoots appear from thick root stocks up to 15 inches in diameter which are immensely old. The annual rings are distinct, but as the majority of the stumps are hollow; their age could not be determined exactly, but some trees are certainly well over 200 years in age, and the average of the stumps seen at Ahmedwal railway station was well over 100 years. The roots run far into the soil and the Taghaz tree performs a most useful service in fixing the sand dunes, when other species, and particularly the grasses mentioned above, hold the surface of the dune in place.

Excessive grazing destroys this surface vegetation and the sand drifts and is blown about by the wind. Recently the roots of the Taghaz trees have been dug up for fuel for Quetta and for encampments. At Ahmedwal railway station there was a dump of 1,500 maunds of Taghaz roots. This tree should be strictly preserved as with its deep root system, developed over centuries, it serves to fix the sand dunes which otherwise will advance towards the east. An advancing desert accompanied by general aridity is the future of the Chagai district if grazing and exploitation of the natural vegetation for fuel be permitted without efficient control.

Already far to the east at Mustang a hamlet and surrounding orchards have been overwhelmed by drifting sand and the gaunt walls of the houses alone bear witness to homes which have been destroyed.

In the desert, as in more favoured localities, the destruction of the vegetation is followed by soil and wind erosion. To preserve the country, side the grazing of sheep and goats and camels must be limited to what the natural vegetation can support and the grazing must be rotated in order to allow such vegetation as exists to recover.

General

Enough has been written to show that throughout Baluchistan the natural, undisturbed vegetation was formerly much more

abundant, and consisted of more diverse and higher types of plants which survive now only where they have been protected, or, like the Juniper and Olive, have a length of life far greater than the human span.

Before the British occupation the villages were small collections of huts or mud houses, near small patches of cultivation, which the people defended from their enemies as best they could. Most of the people were shepherds who moved their simple tents or built fresh temporary shelters as they exhausted the pastures, or when at the natural change of season there was a fresh flush of vegetation at higher or lower altitudes. Immigrant shepherds had to placate the tribesmen, or to fight for a footing in the country. There were no large towns whatever, and the people, limited in numbers as were their domestic animals, were not more than the country could support.

The British occupation has, in spite of occasional setbacks, brought peace and prosperity to a troubled land, and, although the population has not increased, flocks of sheep and goats have multiplied manifold, and more and larger migratory flocks traverse the valleys *en route* to and from the plains or remain to graze with Government's permission.

Cantonments, together with their accompaniment of camp followers, have been established in various localities, and these centres of population are new factors which are not indigenous to the country. They have made demands for fuel, both of trees and of bushes which are dug out by the roots, for meat and milk, with the result that the forests in their neighbourhood have been denuded.

Cultivation.—Throughout Baluchistan the rainfall is low and varies from year to year, but increases with elevation up to 10 or more inches. The principal cereal crops are wheat, maize and millets, the last being grown as much for fodder as for grain. Most of the rain falls from mid-December to March and in July; but occasionally there are severe thunderstorms, especially in April and May, when much rain falls in a very short time and does more harm than good, as the floods break the embankments. Land is plentiful, water for irrigation is short, and it is customary to cultivate the land for one year and to let it lie fallow for three years or less, in order to restore its fertility. No fields at a distance from the homestead are ever manured.

In many parts of Baluchistan, particularly in the Barkhan tehsil, less in the Quetta-Pishin district, the standard of arable cultivation is very high indeed, and the local cultivator has nothing to fear in comparison with the rest of India. Water is conserved to the best advantage, and if a little more attention were paid to drainage and the prevention of damage to the embankments by rats there would be no avoidable soil erosion. The shortage of man-power makes it difficult to do more than is done at present.

The following methods of cultivation may be distinguished in the upland tracts with which alone this note is concerned. Classes (i) and (ii) contain fine fruit orchards.

(i) *Perennial irrigation from springs and streams*

Fair crops are produced where water is available for irrigation. Where the fields are terraced, are level and are bordered by peripheral embankments, they are permanent and are cultivated for wheat, maize and millets, and garden crops and occasionally, for example near Harnai, for rice. Where fields are cultivated without proper levelling, there is much soil erosion, as in the neighbourhood of Quetta. The practice of fallowing for long periods leads to the neglect of the bunds, which are undermined by rats and near the edges of the plateau both sheet and ravine erosion are severe and ravines are extending, particularly in the Quetta-Pishin district.

(*ii*) *Perennial irrigation from a "karez" or underground water channel driven into a talus at the foot of a hill.*

The fields are cultivated and fallowed in rotation. The extent of land available is greater than that for which there is "karez" water, and advantage is taken of favourable rains to extend the area cropped. Where the fields are level and embanked they are permanent, but in years of heavy rainfall the bunds are broken by storm water, as there are no weirs to regulate the escape of flood water. Erosion is taking place in a manner similar to that described at the end of the previous paragraph.

(iii) *Inundation from the rivers*

In July and August and whenever the rivers are in flood their waters are utilized to inundate the fields. Good examples were seen in the flood plains of the Narechi and Anambar rivers, where there is room for expansion of cultivation

but labour is scarce. Every drop of water of the Kaiser river is also utilized for inundating the fields.

(iv) *Inundation from torrents when in flood*

The beds of the torrents which issue from the hills are dry for the greater part of the year, but when rain falls there are sudden spates or floods which rise and fall with great rapidity.

(*a*) In broad valleys of the hills the stream is canalized by embankments and spurs, and on one or on both banks stone walls or earthen bunds are built along the contours. The silt-laden water is diverted and held up by these walls and silt is deposited, until after a few years terraced fields of great fertility are formed.

When the nullah is in flood the storm water is led to these fields and the soil is moistened and in due course is sown with cereals.

(*b*) At the foot of the hills the flood waters of the torrents are diverted by means of stone and brushwood spurs and by stone or earthen dams to elaborately terraced, level fields, on which the waters are ponded up behind very substantial horizontal peripheral earthen bunds, or "latts." There are most elaborate customary local regulations for the use of this water. The differences in level between the fields are frequently very considerable, bunds or "latts" of eight or ten feet in height being by no means uncommon in the Barkhan tehsil. Rats do much damage, as they burrow in the bunds which are liable to be breached by the water which pours down in a devastating flood. Proper stone weirs are required to regulate the inflow and the outflow of the water to and from the fields, but the villagers say that they cannot afford them.

These methods of utilizing flood water are excellent and are as well developed as can be expected with purely local resources. Irrigation officers might be able to improve on them by building proper regulators and escape weirs at Government expense at selected centres as demonstrations of correct methods; they might study the behaviour of the torrents, as the violence and frequency of the floods have increased by reason of erosion of the catchment areas, and the villagers are finding it more and more difficult to deal with the floods. Bunds are frequently broken and fields lie derelict after their surface has been eroded by flood water.

(v) *Fields formed by blocking valleys with earthen dams*

Near Barkhan a valley has been blocked by two huge privately-constructed dams and a third is in course of construction. Some idea of the magnitude of the effort is given by the dimensions of the middle dam, which is roughly 900 feet in length, 20 feet in height, with a substantial broad base. The dams are formed of closely-packed earth with escapes cut through the rock on one side, in which are regulators by means of which the height of the water can be controlled. The object is to pond up the water behind the dam in order that it shall deposit silt, which will get deeper from year to year and will be moistened by flood water.

On the night of 6th/7th June, 1944, one and a half inches of rain fell in three-quarters of an hour, storm water poured down the nullahs and burst the dams for the reason that the escapes were too narrow and the regulators were closed.

What was apparently the cement foundation of an ancient dam were seen, which had probably been destroyed in former floods, but of which there is no memory.

The catchment area is bare and is grazed heavily every year, which means that the water runs off the surface very rapidly and that the violence of the floods is greatly increased. Closure by grazing would certainly help to reduce the violence of the floods, but would be resisted by cultivators.

(xi) *Dry cultivation in embanked fields called "Khushkaba"*

(*a*) In regions of low but adequate rainfall the fields are terraced, levelled and surrounded by an earthen embankment, locally called a "latt," by means of which the rain water is constrained to soak into the soil of the field on which it falls. By these means the whole of the rain water is conserved and the crops produced are better than those on unlevel ground.

(b) Where the fields lie below the hills advantage is taken of the rain water which falls on the slopes above the fields to increase the amount of water for the crops. The fields are levelled and embanked as before; along the slope channels are built by means of which storm water is conducted to the fields. This enabled crops of wheat to be grown in regions where the annual rainfall is as low as 5 inches, as in Chagai district. This latter method is half way between "sailaba," or inundation cultivation, and true "khushkaba," or dry cultivation, on which it is an improvement.

Cultivation is precarious and, except in favourable years, does not extend over more than one-quarter to one-third of the arable area available.

Rats do much damage to the "latts", while in storms the embankments are broken by reason of the failure to provide proper stone escapes by means of which the amount of water admitted to the fields can be regulated and limited to the volume which the "latts" can support.

The process of levelling

Fields are levelled mainly by the use of the "khal", or bullock-drawn earth scoop. Levelling is not completed at one time; the "latts" are built first in order to pond up the rainwater, the soil is ploughed and the rainwater is allowed to bring down the loose earth to help in the process of levelling. Catch crops are sown in order that the ground shall be utilized during the process of levelling, which takes a few years where the slopes are at all steep.

(vii) *Dry cultivation without embankments in the Pishin district, also called "Khushkaba"*

The flat plains near Pishin are cultivated by tenants-at-will without making any attempt to conserve rainwater. The soil is a light loam with varying proportions of sand and clay. After rain has fallen the land is ploughed once, sown broadcast with wheat and harrowed. Very thin crops of wheat are produced which are full of weeds (camel thorn). The tenants do all the work, and take five-sixths of the crop; the landlord spends nothing on improvements and takes one-sixth of the produce. The low hills beyond Kila-Abdulla and near Inayat Ullah and Gulistan are cultivated in a similar manner and the crops this year were very poor indeed. The basic reason for the slack method of cultivation without embankments is the lack by tenants-at-will of any permanent lien on the land, as the land is allotted to them for one season only and there is no certainty that they will be able to cultivate the same fields in the next year. Consequently the tenants make no attempt to improve the land; they plough it once only, and as there is no shortage of land they plough as much as they are able, which is not considerable, as they are short of plough bullocks and use camels and donkeys instead, as these animals are easier to feed. Should they be lucky and should rain fall in time and in sufficient amount the crops are good; but should rain be delayed or should drought be long continued, as often happens, the yield of wheat is exceedingly low. Cultivation of this nature is a gamble in rain.

Soil erosion in Pishin district

Erosion in the hills is serious and this is due here, as elsewhere, to the destruction of the vegetation by over-grazing.

There is much sheet and ravine erosion in the plateaux. As a rule the irrigated lands are stable; but the practice of fallowing for several years results in the fallow fields being neglected. Rats burrow in the bunds and weaken them, with the result that when rain falls the water escapes and flows into ravines which are extending.

Where the surface of the "khushkaba" field is sloping and there are no bunds, sheet erosion of the top-soil is severe; plateaux near the main lines of drainage are ravined and ravines are extending.

Erosion follows on slack and faulty methods of cultivation, and these are due very largely to the unsatisfactory uneconomic relations between landlords and tenants. Recently in the Punjab an act (Act IV of 1944) has been passed by which Government has the power of compelling the owner and, where there are occupancy tenants, the tenants to put their lands in order. Should they fail to do so, Government may do it for them and recover the cost up to a value of ten times the land revenue of all lands possessed or cultivated by them. This may result in improved cultivation; otherwise it may be necessary to revise the tenancy laws.

Use of tractors for "Khushkaba" cultivation

There is a shortage of labour, as the local inhabitant prefers the life of a shepherd to that of an industrious arable farmer. There is a shortage of plough bullocks, which are difficult to feed, as there is little grass and "bhusa" (straw) is expensive, with the result that in many places donkeys and camels are used to plough the fields, particularly the latter, as they browse on the camel thorn weed and salsolaceous plants in the waste. It has therefore been suggested that upland valleys should be ploughed by means of tractors.

From what has been written above it will be seen that the conservation of water by means of terracing and embanking is an essential preliminary to arable cultivation. Accurate levelling and the building of peripheral embankments along the lower edges of each terraced field would be essential. This presumably would be done by graders or "bulldozers" such as are used to level aerodromes. Water from the hillsides would be led on to the fields where practicable in order to moisten the soil sufficiently for the growth of wheat. I do not think that it would be worthwhile to plough the fields by tractors without "lattbundi"; *i.e.*, level embanked terraces; it might succeed if rains were particularly favourable, but the odds are against it, and should the rains fail the crops would fail also. As the fields would necessarily be large in order to permit of the economical use of machinery, proper drainage would be needed.

In the Punjab the moisture in the soil under dry cultivation is conserved by frequent shallow ploughing whenever rain falls, up to twelve times or more in the course of the year; in Baluchistan this is not customary and the fields are ploughed far less frequently, but the greater the number of ploughings the greater would be the yield of wheat.

Tractor cultivation is not a simple solution in itself, but must be accompanied by levelling and embanking, by adequate drainage and by good and proper tillage, otherwise the crops would be poor and the yield so small as not to repay the costs of cultivation.

Engineering works

Along and above the roads hundreds of miles of contour drains and diversion channels have been built many years ago in order to prevent stones and silt being spread over the roads. Some are useful but the majority have not proved their worth, but they show that the menace of soil erosion has been appreciated by road engineers for many years past.

Many stone embankments and spurs, often bound with hercules wire netting, have been built to prevent the floods from breaching the roads and railways, but in spite of all precautions floods do much damage annually and in 1944 communications were badly interrupted. The total cost of protective works must have been very great. In my opinion the threat to communications is increasing by reason of the disappearance of vegetation, which is now insufficient to check the flow of water over the surface of the ground.

SUMMARY

After a most careful study of conditions in representative sections of each district, I have come to the following conclusions:

(i) *The extent of soil erosion*

Throughout the hills there has been very severe erosion of the soil. Where the underlying rock consists of limestone, or other hard rocks the soil has disappeared; where there are shales or soft earth, gullies have formed.

Along the main migratory routes the soil is naked and is eroding with extreme rapidity; for instance, in the Dilkhuna gorge.

The torrents come down in dangerous spates and debouch with great violence on to the upland plains, in which they fan out and wash away the surface soil. The violence of the floods makes it difficult to build and maintain inundation dams and channels and the fields are threatened. The threat to road and rail communications is increasing.

In the gently undulating upland valleys surface erosion is universal.

Near the main lines of drainage the edges of the plateaux are fretted with ravines which extend far into the cultivated lands of the Quetta-Pishin district and are increasing. In other districts ravines are present, for instance, near Loralai, but they are not so severe for the reason that these districts are less heavily cultivated.

Where the fields have been levelled, embanked and intensively cultivated, soil erosion has been reduced to a minimum.

Where slopes have been ploughed without terracing or embanking, sheet erosion is severe and ravines are extending rapidly. Where

irrigated fields are either inadequately levelled, as near Quetta, or allowed to lie fallow for one, two or three years as is common everywhere, erosion of the fields near the ravines is severe and the ravines are extending.

Wind erosion has been mentioned, and the function of the vegetation in preventing the drift of sand, particularly that of the Taghaz tree (*Haloxylon ammodendron*) has been described. At Mustang sand dunes are drifting across the road, driven on by the north-west wind. Houses, fields, orchards and one irrigation channel have been overwhelmed and buried under sand; villages have been wholly or partially abandoned and more are threatened; graveyards have been covered with sand. A closer examination of the sand dunes shows that scattered plants are endeavouring to obtain a footing and spread in the sand dunes, and undoubtedly they would do so eventually and they would succeed in holding the sand in place were it not for the voracious animals—sheep, goats and camels, which browse in the sand dunes. Among the most common species were *Sophora griffithi*, *Salsola* sd., *Haloxylon* sp., *Othonnopsis intermedia* which is not eaten and is regenerating, *Euphorbia* spp., Harmal, a couch grass (*Cynodon ?*), *Heliotropium eichwaldi* and other plants which were not identified.

The herbs and grasses are doing their best and, if left alone, would fix the sand, but man's domestic animals devour them and ensure that the sand dunes shall march steadily forwards until they are arrested by the barrier which the hills oppose to their further progress.

(*ii*) *The causes of soil erosion*

The main cause of soil erosion is excessive and unregulated grazing.

Faulty methods of cultivation are the cause of much soil erosion in the Quetta-Pishin district, and sometimes elsewhere, as long the Mustang road.

(*iii*) *The cure*

The cure for soil erosion is the proper management of the pastures; the limitation of flocks to the numbers which the vegetation can support; and closure to grazing in rotation are the cures for avoidable soil erosion in the greater part of Baluchistan. The elimination of faulty methods of cultivation would prevent soil erosion in cultivated lands.

It is not easy to set back the clock. Any attempt to do so must necessarily mean a complete overhaul of policy in relation to rural economy with a view to the improvement of the vegetation and the prevention of soil erosion throughout Baluchistan, rather than the nominal protection of a small area of reserved forest and half-hearted attempt at the preservation of trees of a few reserved species in the village waste.

The forests, pastures and arable fields all form parts of one estate, which must be managed properly in the public interest. The policy will aim at the protection and increase of vegetation throughout Baluchistan; its proper and regulated use in order to provide a permanent yield of vegetable and animal products; for example, medicinal herbs, timber, firewood, sheep, goats, cattle, riding and transport animals; the conservation of the soil of the "waste"; the prevention of floods; the conservation of the soil of the fields; the conservation of water; the extension of arable cultivation in the upland plains. This may be summed up as the use and not the abuse of natural resources. Plans will provide for the management of the estate as a whole, in order that man and his domestic animals may live in harmony with their environment.

It is easy to suggest remedies; it is far from easy to put them into effect without upsetting the political, social and economic life of the country, and yet a change to proper management of the whole estate must be made now unless the natural resources of the country are to dwindle to vanishing point. The first task is to persuade the local people themselves of the need for conserving the vegetation; the second is to design and put the necessary measures into force; the third is to regulate the use of the pastures by migrants from outside.

Conclusion

It is hoped that now that the seriousness and extent of soil erosion have been brought to the notice of the Baluchistan Government firm action will be taken. If not, the country will suffer from a constant lowering of productivity, and will be unable to maintain even its present scanty population.

—*The Empire Forestry Journal*, Vol. 24, No. 1, 1945.

GENETICS AND FORESTRY

By H. G. Champion

(The following paper was written as a contribution to a symposium held in London by the Genetical Society, on April 13, 1944, on the "Application of Genetics to Plant and Animal Breeding." A brief summary of the paper presented was published in *Nature* (Vol. 153, p. 780, June 24, 1944), but it is thought that the fuller account will prove of interest to foresters.)

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(1) *Scope for Genetical work in Forestry*

The field offered by forestry for the application of the results of genetical research is greatly influenced in comparison with agriculture by the great length of the generation of the forest tree, and in comparison with horticulture and the raising of other tree crops such as rubber or cocoa, by the low value per unit. Forests again are mostly of natural origin and have usually been regenerated from self-sown seed, and the opportunities of bringing about genetic improvements tend to be proportional to the extent to which circumstances have brought about a change in this practice in favour of sowing or planting, *i.e.*, the adoption of what the forester terms "artificial regeneration." It so happens that to an extent greater than any other country in the world in relation to the total forest area, Great Britain now practises this artificial regeneration. We have cleared by far the greater part of our original forests and are only now laboriously trying to reconstruct a few million acres, mainly on our poorer soils and moorlands, all by planting out nursery stock. Even in our remaining semi-natural woodland, by far the greater number of trees we see have been planted or descend from planted trees, even though they are of the indigenous species, oak, ash, beech or pine, one of the main reasons for this being the difficulty or slowness of spontaneous seeding.

One consequence of this largely unavoidable dependance on artificial stocking is that we can if we wish have almost complete control of the stock of which our future forests shall consist. Not only species, but genotypes can be selected at will from all that are available, so that it is obviously a matter of the greatest interest and importance to push an intensive study of the genotypic variations present in all the species we wish to grow and to determine which of them is best suited to each set of conditions of climate, site and soil, and how to handle them to get the best results. Only if it could be demonstrated that the amount of variation is unimportant or that selection is quite impracticable, could it be represented that forestry research could afford to neglect the study of genetics.

It may be asked, what evidence have we of inheritable variation within our common tree species? Owing to the practical difficulties of investigation which will be discussed later, information is not as precise as for many short-lived plants, but much experimental work has been done in the last 40 years and the demonstration is freely available that these trees are in no way different from the other plants. The majority of them, especially those of wide geographical and ecological range, exhibit a wide range of variation and the variations are passed on to the next generation in a way clearly indicating genetic differences. These variations affect characters of the greatest importance to practical foresters; a long list of them might be drawn up, but for present purposes it will suffice to mention only a few of the most important.

Foresters are usually primarily concerned with timber production, so rate of growth is of special interest. Very numerous investigations have been made to compare results with samples of seed of selected species, particularly *Pinus sylvestris*, *Larix decidua* and *Quercus sessiliflora*, from a number of different stations, and all have shown very marked differences. Some of these investigations have been continued to the second generation in the new habitat and indications obtained that the differences still persist. Almost as important as gross rate of timber production is the form of the bole, as losses on sawing and the quality and value of the timber obtained, are much affected by the straightness of the main stem, its freedom from heavy branching, and degree of taper. Here too the clearest evidence is available that these factors characterize different races or strains, the most conspicuous examples being among the pines, *Pinus sylvestris* and *Pinus nigra*. Other

properties of timber may affect its value considerably, *e.g.* the colour and figure, the straightness of the grain; and the physical and chemical properties, and here, too, there is abundant *prima facie* evidence, and not a little experimentally proven, of genetic variation and inheritance from a variety of trees such as poplar, birch and pine. A different type of character, *viz.*, yield of products other than timber, has similarly been found to vary genetically providing a link with the more studied economic tree crops. Instances are resin and latex yields, tannin, oil and dye content.

Rate of growth itself links with phenological characters and these may be of much significance in relation to hardiness to pathological influences whether physical or biological. Thus an early leafing form is often more liable to be affected by late frosts, and damage by frost may not only depress the growth of the year, as conspicuously in beech, but may render the affected plant more subject to attack by injurious fungi, as seems to be the case for larch canker, or by insects. Attacks by fungi and insects generally are much influenced by the condition of the foliage at times related to the life history of the pathogen. The best known forest example of inherited variation in this respect is Norway spruce with late and early flushing races each characterized by a number of other associated characters. Marked differences in susceptibility to fungus attack causing needle cast have been found to characterize the races of *Pinus sylvestris* and a good deal of the difference in later development may be traceable to influences such as these which prevent the young tree from getting a good start.

A point of difference between the raising of forest tree crops and other tree crops such as fruit or rubber, is that whereas in the latter we only plant out and tend the number suitable for the area in use, in the former we always plant out a great many more, commonly at least ten times as many as we expect to finish with when maturity is reached. The rest, 90 per cent. or more, will be gradually removed as thinnings, and if this operation is properly carried out, the poorer individuals are steadily eliminated. Many of the trees removed will owe their defects to accident and not to genetic inferiority, but in the long run inferior heredity will lead to removal, and the final crop will tend to be predominantly the best genotypes. There is a point here which must not be overlooked, *viz.*, that a constitution carrying great vigour in early growth may be associated with undesirable characters in shape, etc., only apparent later on, but these too are looked for and provide reason for removal when thinning even if they affect the biggest and strongest trees in the crop. This reduction of numbers often takes place even more markedly in natural regeneration as the initial numbers may be much greater. Elimination is determined in the first place by relative vigour, weak seedlings and saplings being shaded out by their stronger or better placed neighbours, but subsequently the same conscious selection is applied. This is a matter of importance when seed collection is in question.

(2) *Work done in Forest Genetics*

The most extensive work done so far has been in the field of "Provenience," *viz.* comparative studies of the results obtained at one station with samples of seed of a chosen species collected at a number of different and widely scattered stations. These investigations were promoted by the fact that in many parts of the Continent crops raised from seed obtained from elsewhere were markedly inferior to existing crops of local origin: the classic case was the highly unsatisfactory form of *Pinus sylvestris* raised in parts of Germany from seed collected (more cheaply) in Southern France. There were at least two possibilities to be considered, *viz.*, that the imported strain was inherently inferior under any conditions, or that the inferiority was due more to unfavourable reaction to the different climatic conditions. In 1906, an international investigation was organized to study Scots pine in this respect, and despite inadequate initiation or maintenance in the majority of stations, has yielded most valuable results; a very wide range of characters was found to be inherited in the several origins. A recent summary is to the effect that: "The introduction of races which have been differentiated under certain climatic conditions into regions with different conditions even within the natural distribution of the species leads to serious losses in all directions: even inside one country, transfer between regions of markedly different climate is unwise." Although, in general terms the outcome of such Provenience investigations is to indicate the local autochthonous form to be the best for local use, over a wide range certain good strains may give better results. Very many plantings of imported origins made without any specific

intention of experimentation provide evidence substantiating these deductions, but in all too few cases, is any really reliable evidence forthcoming as to the ultimate origin of the seed used. In this country, one of the most interesting indications is the relatively superior results which have several times been obtained with *Larix decidua* collected from Scottish stands, themselves, of course, of imported origin. It may be surmised that there has been a tendency to retain to a higher age stands which were doing best and to collect seed from such preselected good stands, plantations of origins less well suited to British conditions having been largely eliminated by earlier felling.

These Provenience experiments have rarely paid any special attention to the individual parent tree. It has been taken that most or all trees of a natural stand or a single planting were of equal genetic value, any relatively poor stems being deemed phenotypes due to chance inequalities in growth conditions. A certain amount of work has been done on seed collected from selected mother trees, but as cross pollination is usual, the pollen parentage has been unknown and this has been thought adequate to account for partial failure to maintain purity of type. Examples of such work include studies on the early and late shooting spruce, on spiral grain in pine, and leaf colour in beech. The unsatisfactory procedure has been followed mainly, of course, on account of the practical difficulties of controlled pollination in forest trees and it is only of recent years that studies based on selection of both parents have been undertaken.

In 1925 the Eddy Tree Breeding Station was started by Lloyd Austin to develop the technique and apply it for research and practical purposes, and a good deal of work has been done in Europe of late, notably in Sweden by Nils Sylven and others. In view of the interest of species hybrids and the sometimes striking features shown by some of them in other types of plants, studies have been made of the relatively few natural tree hybrids which have been found and breeding stations have attempted a big range of crosses. The natural crosses which have attracted most attention have been those between the two commonly grown species of *Larix, L. decidua* and *L. leptolepis*, and those of the poplars, *Pgenerosa* in the first instance. These first crosses showed every indication of special merit in possessing what is usually referred to as "hybrid vigour" and it was hoped to obtain more like them.

The further stage on which foresters are now embarking is the study of induced mutations, some of which, it can be hoped, will prove to carry desirable characters. This subject will not be discussed in detail since it is thought that no principle not already familiar to botanists has been discovered. The most promising line has so far been the production of polyploids. These may, of course, occur naturally, and a triploid aspen has been found in several localities in Sweden and has the same desirable character of rapid growth as the hybrid larches and poplars. Crossing experiments with this triploid giant aspen with the normal diploid have given a variety of forms including a very vigorous tetraploid but others less so. The induction of chromosome changes by various physical and chemical treatments is under study at several stations.

(3) *Technique of genetical studies on forest trees and practical application of results.*

The field of forest genetics has often been neglected because of the practical difficulties of research work and of the application of any promising results which might be obtained. They have been made the excuse for the serious neglect in this country despite the fact mentioned at the outset of our exceptionally favourable conditions for profiting from discoveries, but they have not deterred a small country like Sweden where forest regeneration is usually by self-sown seed or even Denmark from devoting much attention to tree genetics. There are, admittedly, difficulties some of which have already been mentioned, and it is well to review and face up to them. On the other hand, there are many indications that there has been a tendency to magnify them, and that they are by no means insuperable.

We begin with the difficulty of distinguishing between the effects of heredity and environment: mature trees take up so much room that it is impossible to guarantee that any two have grown under identical conditions both above and below ground level. Controlled pollination on most forest trees, particularly those grown in closed stands which alone can show actual or potential timber production characters, and which usually only produce seed at a late age and high in the crown, is obviously not easy and requires special appliances; moreover, self-sterility is common, and several important

species seed freely only at long intervals, beech being the most pronounced example of this. Even with species which will produce seed at a relatively early age, a long period of years is necessary to reveal fully timber form and properties. The large area required to raise even small crops of known parentage is not only a physical handicap, but carries with it the uncertainty as to variations in site, and hence the need of many replications for conclusive results. Not only is a large area needed, but a large number of plants is required to give the stand which must be the ultimate unit for comparison. Here, however, many methods are available for spacing out the selected stock among ordinary stock which will be removed during thinnings.

When the investigations cover hybridization and F2 and F3 have to be studied, the time required with ordinary methods may appear to be impossibly long owing to the slow sexual maturation of trees—and yet this has already been done for important factors such as seedling vigour and frost resistance in certain pine hybrids since 1925. Finally, as already noted, individuals which are backward in the seedling and sapling stages may possess compensatory advantages and even subsequently more than make up for their slow start, so they, too may have to be kept some years.

Desirable races having been thus laboriously isolated, stock of pure strain is required in quantities adequate for use on a practical scale. Controlled pollination is impossible for this, and effective isolation almost equally so as the pollen is so usually wind borne; and there is the big time factor. Vegetative propagation is practicable for a few genera such as the poplars, but is decidedly difficult for the majority, often hitherto quite impracticably so—as with pines. Accordingly, much searching is in progress to get over these admitted difficulties, and there is no reason why success should not be obtained. Various effective methods for bringing about early seed production are known involving grafting and ringing, and these do expedite research work even if not as yet suitable for adoption on a large scale. Progress in the technique of artificial regeneration including the use of various stimulants to rooting has already been very marked and there is no reason to think the possibilities are anywhere near to being exhausted. Many properties of importance can be examined on single plants in the sapling stage, and comparative studies made on ample (and suitably arranged) single plant replications, without waiting for the larger crop plots to grow up; such studies will often give adequate indications as to which forms merit study to the later stages.

(4) *Practical application of genetical knowledge in forestry.*

Enough has been said to show that the prospects of securing better and larger yields in forestry through genetical studies are definitely promising, and even if it were only a question of avoiding mistakes, there is the strongest case for prosecuting research in this country. It remains to consider what immediate steps might be taken.

The first and simplest is one that has been urged for many years with very little result, though it is common practice on the Continent. It is to mark down, preserve and tend primarily for seed production, an adequate number of obviously superior groups and stands of trees of the major species in each climatic region where the species is to be planted, hardwoods as well as softwoods. It may be desirable to fell inferior stands in the neighbourhood to minimize risks of undesirable crossing, as has been done in Germany. Some of the most conveniently situated of these "living seed stores" might be used for research studies along the various lines we have reviewed. Unfortunately, many stands that were potentially far more valuable to the country for this purpose of seed production than for the contribution they could make to war supplies of timber, have been felled during the past four years, but it still remains to make the best of what is left and opportunities are not entirely lacking.

The next step which should be introduced at the first possible moment, but can only follow that last discussed, is seed certification. It ought to be possible to take it for granted that any seed or nursery stock issued by the State Forestry authorities for use on State or private forests should carry the requisite guarantee, not merely as to locality, of origin (owing to the prevalence of planting, very poor types are often to be seen in localities known as producing very good ones) but as to quality of parent stock. Directly seed supplies are available, State aid to private planting should be made conditional on use of certified stock and of the nurseryman's and tree seedsman's

trade will not meet the consequent demand, the State should itself accept responsibility. The contract between these two measures and the far too common practice in British woodlands of the periodic felling of the best trees in a stand, as selected by the timber merchant retaining the worst as the parents of future generations, must be noted; hitherto, such selective processes as have been applied have been of a definitely dysgenic nature.

Meanwhile, genetical research for application to forestry should be organized at once with staff and facilities proportionate to the large amount of work needing attention. Delay or inadequate provision will result in the commission of avoidable mistakes with which forestry will be saddled for a whole tree generation. Some aspects of the work to be done are of a highly specialized technical type which can best be carried out in, if not by, existing research stations for genetical studies, but most of the field work, especially the unavoidable large-scale, long-term studies, requires facilities unlikely to be obtainable anywhere other than on State forest lands. It must therefore be done by or with the fullest co-operation of the Forestry Commission. The subject is unfortunately rather summarily disposed of in the recent official White Paper on Post-war Forest Policy, but it can be hoped that reconsideration is not ruled out and it is recommended that the Society should actively support any steps to secure this end, if indeed it should not itself take the initiative.

—*Quarterly Journal of Forestry*, Vol. XXXIX, No. 2, July, 1945.

MANURES AND MANURING—VI*

FARM PRACTICE WITH FARM MANURES

By Sudhir Chowdhury.

In considering the plant-food value of farm manures one has to keep in mind that it is an essential product of the farm, and that it must constitute the main source of manure for the land under the condition of ordinary mixed farming where special manures will only be used as supplements and not as rivals. As a fertilizer, the chief value of farm manures lies in the fact that it contains all the elements of a plant's nutrition—nitrogen, phosphoric acid, and potash,—though for a well-balanced manure the phosphoric acid is comparatively deficient. Moreover, the nitrogen is present in various forms of combination, varying from the rapidly acting ammonia compounds down to some of the undigested residues which will remain for a long time in the soil before becoming available to the plant. In consequence farm manure is a lasting manure which accumulates in the soil to build up what a farmer calls 'high condition.' As mixed form manure contains on the average 0·50 per cent. of nitrogen, 0·25 per cent. of phosphoric acid and 0·60 per cent. of potash considerable quantities of plant food elements are added in an ordinary application.

The value of farm manures to the land is by no means confined to its fertilizing action, its physical effects upon the structure of the soil are equally important. In the first place, manure as it rots down produces humus. This humus increases the absorptive capacity of the soil. In clay it promotes granulation, while in sands it acts as a binding agent. Under all conditions it promotes granulation and improves tilth. The capacity of a soil to resist drought is raised, its aeration is increased and drainage is promoted. All these changes tend to benefit plant growth.

From the chemical standpoint, the presence of farm manures in the soil tends to increase organic acids, notably carbonic acid. The soil minerals are thus rendered more easily soluble. The humus may also combine with certain of the mineral elements and hold them in a form more easily available to crops. Nor is the chemical influence of farm manures the final effect. The modification of the soil flora can by no means be passed by. Not only are millions of organisms added by an application of manure, but those already present in the soil are vastly stimulated by this fresh acquisition of humic materials. Nitrification, ammonification and nitrogen-fixation are also increased to a remarkable extent.

*Continued from previous articles which have appeared in the *Allahabad Farmer* and some of which have been reproduced in the *Indian Forester* in 1943 and 1944.

Application of Farm Manures

The old-fashioned and well-known maxim 'too much of a good thing is bad,' true of so many processes, associated with agriculture, is no less true with regard to the application of farm manure. The best results have been found by experiment to be got from comparatively light uniform applications rather than from extremely heavy ones, and more of the beneficial ingredients of the dung in proportion to be used by the plants. It used to be quite a common practice to apply anything from 15 to 30 tons per acre once in a five or six year rotation, with none in between. This, of course, is obviously bad practice and experience and research in more recent years have shown that 2 to 10 tons per acre, supplemented by suitable combination of special manures, depending of course on the quality of the manure, the soil, and the particular crop, applied each third or fourth year when conditions are suitable, are ample and to be preferred.

On light sandy soils, it is advantageous to apply well-rotted manure rather than that only partly decomposed, and it is well to apply it just before the crop is sown. The reason is that the short straws and fibres of well-decayed manure tend to firm up these open soils, whereas the long undecomposed fibre in fresh manure tends rather to open up a soil. Further, if the manure is put down too long before the plant is able to avail itself of the soluble matters, then they tend in these soils to get rapidly washed down out of reach by heavy rains.

In heavy soils, clay or otherwise, on the other hand, it is far better to apply much fresher dung, a considerable time before the crops need its substance. The undecomposed long straw open up these stiff soils, loosen them, and so aerate them, and help to drain them ; decomposition of the manure takes place actually in the soil, having its effect on the organic, and also on the mineral constituents of the soil themselves, and so effecting a change in them from a dormant to an active condition.

Distribution of Farm Manures in the Field

In the actual application of farm manures to the land, certain general principles should always be kept in mind. In the first place, evenness of distribution is to be desired, since it tends to raise the efficiency of the manure by encouraging a more uniform plant growth. This evenness of spreading is much aided by fineness of division. Moreover, it is generally better, especially in diversified farming on medium to heavy soils, to decrease the amounts at each spreading and apply oftener. Thus instead of adding 20 tons to the acre, 10 tons would be applied and twice as much area covered. The applications would then be made often. A larger and quicker return in net crop yield per ton of manure applied would be realised. This has been strikingly shown by the Ohio experiments over a test for eighteen years in a three-years' rotation of wheat, clover and potatoes, the manure being placed on the wheat and affecting the clover and the potatoes as a residum. The results are expressed below in yield per ton of manure applied :

	Wheat (Bushels)	Clover (Bushels)	Potatoes (Bushels)
4 tons to the acre	8·0	177	37·3
8 tons to the acre	4·1	150	19·3
16 tons to the acre	2·4	99	11·6

Not only is the increased efficiency from lower applications apparent, but a great recovery of the manurial fertility in the crops also results. The Ohio experiments have shown that in the first rotation after the manure is applied, a recovery may be expected from a treatment of 8 tons 25 to 30 per cent. higher than from one of 16 tons.

Evenness of application and fineness of division are greatly facilitated by the use of a manure spreader. It is impossible to spread manure by hand and obtain an even distribution. Moreover, a spreader lessens the labour and more than doubles the amount of manure one man can apply a day.

Whether manure should be ploughed under or not depends largely on the crop on which it is used. Ordinarily, however, it is ploughed under. This is particularly necessary if the manure is long, coarse and not well rotted. It should not be turned under so deep, however, as to prevent decay. If manure is fine and well decomposed, it may be harrowed into the surface soil. The method employed depends on the crop, the coil and the condition of the manure.

The Time to Spread Farm Manures on Fields.

If on any account partially fermented manure must be allowed to lie on the surface of fields for sometime before it can be incorporated with the soil, its application should preferably take place just prior to or during fall of rain, in order that the ammonium carbonate may be carried directly into the soil, for the soil readily absorbs and holds ammonia excepting under conditions not commonly met with in agricultural practice.

Importance of Tillage as Related to Manuring

No matter how carefully the manures are handled and applied, full results cannot be secured unless superior tillage is practised. The facts previously stated show that many, if not most arable soils contain vast quantities of potential plant-food, and that the yield of crops raised on them indicates that but a very small fraction of this plant-food is available for the production of any single crop. Jethro Tull and recently others have proved that tillage may be made the great factor in increasing productivity; and it has also been proved that it is not economical to neglect tillage and seek to produce maximum crops by the application of large quantities of manures.

Residual Effects of Farm Manures

The residual effects of farm manures in the soil are of long duration, as the Rothamsted experiments have fully demonstrated. In this connection Hall of the Rothamsted gives the results on grass where stable manure was applied at the rate of 14 tons per acre per annum for 8 successive years (1856—1863), the land then being left in grass without manure for 40 years. These results are compared with those secured on a similar field to which no manure was applied. The greatest increase over the unmanured area was in 1865, two years after the last application was made. The gain in that year amounted to 120 per cent. In the decade from 1866 to 1875 and for the three decades thereafter, the average increase in the produce due to previous applications of manure was 57, 24, 6 and 15 per cent. respectively.

Farm Manures Profitably Supplemented by Special Manures

Where farm manure commands a high price or where the cost of hauling is great, it is usually better economy to employ only moderate amounts and to supplement it with special manures, than to place entire dependence upon it. This is well shown by experiments at Rothamsted in which the use of 200 lbs. of nitrogen in stable manure resulted in a yield of but 27·2 tons of mangel wurzels, as compared with a yield of 33 tons where but 86 lbs. of nitrogen were employed in nitrate of soda, which was properly supplemented with potash and phosphoric acid. The farm manure used with the same amount of nitrate of soda gave a yield of 41·4 tons and when further supplemented by potash and phosphoric acid, the yield was only increased about 0·1 ton.

Farm Manures Compared with Special Manures.

It is not uncommon to see farm manures compared with special manures on the basis of their respective content of nitrogen, phosphoric acid and potash. Such comparison is not believed to be a correct basis for determining relative value, since farm manure serves certain purposes that special manures cannot serve. Farm manures are of very complex composition. They contain more or less all the elements contained in the food given to the animals and in the litter. They are rich in organic matter, being composed chiefly of vegetable substances. This organic matter is a source of humus in the soil and may be of much value.

Those elements of plant food that are found in manures, and which are not ordinarily deficient in soils, as lime, magnesia, and sulphur, are not without their value; yet it has been customary to value manures on the basis of the nitrogen, phosphoric acid and potash they contain. True their value is determined chiefly by the proportions of these elements but the secondary elements are also of value. Soils, moreover, need humus. Farm manures supply this. Special manures do not, and when the effort is made to keep the land in good productive condition without the use of farm manures, it is commonly essential to adopt special measures for the production of humus, as by the occasional introduction of green-manuring crops, or occasionally putting the land fallow. It is true the plant food elements in special manures are often somewhat more promptly available than in farm manures; but while this in itself is an advantage it is also a danger, for the chances of loss are thereby increased. With skilful use the probability of

loss of plant food elements applied in special manures is greatly reduced, and there is considerable experimental evidence to show that a given quantity of nitrogen in the form of some of the best nitrogenous manures, such as nitrate of soda, will increase crops to a greater degree than the same quantity of nitrogen in farm manures. Nevertheless the latter appear to give to arable soils certain qualities which can scarcely be secured except by their use and it will be generally conceded by those qualified to judge that farm manures are sometimes worth more to the farmer and gardener than the figure obtained by estimating at usual trade values the nitrogen phosphoric acid and potash they contain.

Place of Manure in the Rotation

With a number of trucking crops, the application of manure directly to the crop year after year has proved to be advisable. In an ordinary rotation, however, where less intensive methods are employed, it is evident that manure may vary in its effect according to the place in the rotation at which it is applied. This has proved to be the case with special manures and the fact is also becoming recognised in the economic use of farm manures.

In general, hay has derived more benefit from the residual food than almost any other crop in the rotation. At the Pennsylvania Experiment Station, in a rotation of corn, wheat and hay over a test for twenty-five years in which manure was applied in equal amounts to the corn and wheat, the results were as follows:

Percentage Increase from Use of Manure and Value of that Increase.

Treatment	Corn	Oats	Wheat	Hay
6 tons manure ..	37%	28%	73%	39%
Cost $/9 ..	10·85	3·66	9·70	6·55

The same fact has been clearly shown in the Ohio experiments covering a term of eighteen years. The query immediately arising here is: If hay responds so well to residual feeding why not apply the manure directly to it? On this point the following figures from the Illinois Experiment Station may be presented, comparing the response of corn and oats when manured to the yield of clover with the same treatment :

Treatment	Average percentage increase		Total value of increase	
	Corn and Oats	Clover	Corn and Oats	Clover
Manure	11	92	$/7·53	$/10·08
Manure, lime and phosphate	30	141	12·21	15·48

When hay is included in any rotation it is evident that the best results from manure may be obtained by placing it on this crop. This, however, is often not advisable, expecially where the amount of manure is limited.

Commercial and Agricultural Evaluation of Farm Manures

What price should be set upon a ton of farm manure is a question often asked but no general answer is possible, so much depends upon the other conditions prevailing upon the farm. As a rule farmyard manure is part of the normal output of the farm; the farmer has only to make it and use it to the best advantage, he is not concerned with the question of whether it would be cheaper to replace it with an equivalent amount of some other manure. There are, however, occasions when the problem does arise of whether it is cheaper to make farm manure, to buy it or to attempt to replace it by some special manures. It is important, therefore, to try and put some monetary value to it, so that the farmer may attain a clearer idea of the procedure to follow. It is, of course, possible to treat farm manures like any other special manures and value it on the unit system, the result of which would be somewhat as follows. The value of the nitrogen is here placed at ten cents a pound, the phosphoric acid at

two and one-half cents and the potash at four cents:

	Value of Manure a ton
Swine Manure	$ 1·50
Cow Manure	1·64
Horse Manure	1·97
Sheep Manure	2·87
Poultry Manure	4·80
Average of Cow and Horse Manure Mixed	180

Much weight cannot, however, be attached to such a valuation because the unit values are taken from special manures and do not apply to dung. In such valuation the organic matter supplied in the farm manure is not valued; yet it is for the effect of this organic matter on the structure of the soil that farm manure is most generally required. The agricultural value of the farm manures is, therefore, more than its commercial value. The latter is based on composition while the former arises from the effects as measured in crop growth. A manure of high commercial value, may, when placed in the soil, yield only a low to medium agricultural return. This latter valuation is of course the one of greatest significance in agricultural practice. A very good example of this might be cited from the Ohio experiments with manure. In this case both treated and untreated manure were evaluated commercially and were then applied to the land. The value of the increased crops in a three-year rotation was then calculated in terms of return to a ton of manure applied :

Commercial and Agricultural Evaluation of Manures

Treatments	Commercial value	Agricultural value
Yard Manure untreated ..	$1·41	$2·15
Yard Manure plus floats ..	2·04	3·31
Yard Manure plus acid phosphate ..	1·65	3·67
Yard Manure plus Kainit ..	1·45	2·79
Yard Manure plus gypsum ..	1·48	2·76

In practice, then, it is this agricultural evaluation which must be especially watched. Its expression should be not only in net yield to the acre, but also in net return to a ton of manure applied.

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—*The Allahabad Farmer*, Vol. XIX, No. 3, May 1945.

RESEARCH, THE BUILDER OF MARKETS*

By Carl Rishell

(Director of Research, American Forest Products Industries, Washington, D.C.)

The author of this article sees research as the only means of enabling wood to hold its own in competition with other materials. Suggestions are made for a research program that would emphasize particularly (1) improvement in lumber and lumber products and (2) utilization of wastes in the woods and at the mill.

One hundred and fifty years ago the majority of products used by men were totally or partly of wood. If one wants to go further back into history, it is safe to say that at some time or other 99 per cent. of all articles had their beginning in wood. Wood dishes were common. Wood shoes, weapons, houses, vehicles, fireplace chimneys, rakes, plows, hinges, locks and other miscellaneous hardware, clocks, submarines (1776 model), battleships, bridges, buckets, pumps, fire engines, ventilating fans, water wheels, hand luggage, telescopes, carpenters' tools, factory machinery, and literally thousands of other items which are now made of some substitute material were made of wood. The reason for the gradual but steady evolution may be found in the dictionary definition for the word research: "Continued and diligent investigation, a systematic study of certain phenomena by the experimental method." Research as thus defined is the tool which competitors have used for our loss and their gain.

Wood a Target for Substitutes

The present use of substitute materials did not come about because of a scarcity of basic materials from which the commodities are made. There was more iron in the ground then than now. The ingredients for making plastics were abundant. There was oil and coal for fuel, alloys for improving metals, and chemicals to build great industries, but none of these products were ready for use until the efforts of research had made them over.

The one-time holder of all the principal markets in the world has for more than 150 years been the target for every substitute material in common use. Admittedly, some of the markets held by wood have rightfully passed to products having better inherent qualities for the specific use. The passing of the stick and mud chimney should not disturb the equanimity of the most ardent wood enthusiast. The wooden rails used on the early railroads have no place in the modern scheme of things. In retrospect these old wood markets amuse us, but nevertheless they would have saddened the heart of the 1750 lumber trade association executives had there been such a being. Perhaps some day we will view the passing of the composite wood automotive body, or the wood desk, or the library table with the same lightheartedness that we do the demise of the bow and arrows as a military weapon. New materials and new products are constantly appearing and to a large extent these also will be out to capture the markets which we have left to us.

Since most of the substitute materials have qualities which make them difficult to handle or to work as compared with wood, the usual means for overcoming the handicap is to go to the laboratory for the answer. To get even a toehold the cheif competitors for wood markets were forced to build up efficient research organizations. But the lumber industry's markets, like the forests, were so vast that the industry did not feel that it could afford an adequate research program. God grew the forests for us and Providence provided the markets. Our stewardship of these markets has not been brilliant or even intelligent. The other day Secretary Forrestal, when commenting on modern warfare, said, "If we ever have to fight an enemy west of the Alleghenies and east of the Rockies, the war will already be lost." He meant that through improvements to all sorts of equipment the efficiency and speed of modern warfare is so terrific that the fate of nations will be decided long before the weaker antagonist can overcome defects in preparations. This same quotation can apply to any industry fighting to retain its markets. There is probably a substitute for everything the industry is interested in except for adequate preparation, the basis of which is research.

* Presented at Conference on New Developments in Wood Products, New York State College of Forestry, Syracuse University, October 6, 1944.

A Bit of History

In 1918 almost 100 per cent. of office desks were of wood construction. Twenty years later 50 per cent. were of wood. Less than 30 years ago practically all file cases were of wood, but the picture has now changed so that during the last peacetime year about 7 per cent. were made of wood. These are outstanding examples of changing market conditions, but they are by no means unique. There are dozens of other former wood uses that have been replaced either in whole or in part by substitute materials. Examples are automobiles, kitchen cabinets, refrigerators, Venetian blinds, caskets, railroad cars, airplanes, porch furniture, flooring, etc.

The regional and national associations and others in the industry have worked long and hard with the tools at hand to stop or even reverse the trend. No criticism is intended or implied, for without this effort the decline would have been more rapid. Tools have been and still are lacking to defend a weakening position. The two outstanding examples, desks and file cabinets, are worth studying, for in them we will find a clue as to the reasons for our difficulties and perhaps an indication of the solution. An analysis of the situation indicates that we have lost a large part of these markets because of two things, or to be more exact because of a combination of two factors :

1. Price competition, and
2. Unsatisfactory utility over a period of time.

Neither of these factors alone is responsible for the dilemma, but in combination they have become deadly. They may be likened to two weights on opposite sides of a balanced scale, add or subtract from one and the balance may be destroyed. Our competitors have been able to take advantage of this condition. We know the cause for the condition and by years of unpleasant experience are able to evaluate the effect. The problem is to discover and apply the cure.

War Conditions

Immediately after Pearl Harbour "price competition and product utility" ceased in large measure to be balancing factors. Because of necessity the government and the people were willing to pay any price permitted for any desired consumer goods. Quality and price were only secondary considerations. The forest products industry was handed, even compelled to take over, markets which it had been forced to abandon years ago. The opportunity was golden but the requirements so severe that in general we did not have the ability to make the gains secure.

Inability to meet this challenge became evident early in the period. Actually the general use we made of this opportunity will probably be a new and special weapon in the hands of our competitors. That the industry sacrificed itself in a patriotic effort to discharge a war obligation will in no manner affect our ever present war of competition. In many ways we will re-enter this old, old struggle with our moral fibre weakened by excessive indulgence in unopposed markets. We failed to place ourselves in a position calculated to retain these restored markets because the industry resorted to manufacturing processes which in some instances dated back 50 years or even more. These same practices failed us in the late twenties. What we once lost and then gained through the fortunes of war, we will lose again except in those instances where research and product development, quality, and utility have been advanced to outdistance the nearest competitor.

During the first months of raw-material scarcity, wood office furniture was made in large quantities in which every effort was put forth to make wood products similar in appearance to articles of steel. This equipment on first glance seemed to be a fairly accurate replica. The coluor was the same and the general design the same. On desks, for example, a linoleum top had been substituted for the wood surface. It was only in attempting to use the equipment that the very poor quality of the furniture became evident. Drawers fitted inaccurately; construction throughout was of the cheapest and flimsiest type. Many of the desks were sold by firms who had been in the metal desk business for a long time. It even appears that competitors worked out designs and methods for construction calculated to draw public attention to the fact that the wood desk is inherently an inferior product. This statement does not apply to the old-time and outstanding desk manufacturers, most of whom strove to the utmost to maintain reasonable standards. It is quite likely that this cheap material was produced by people who had no experience in furniture manufacture and were working to produce

utility goods in the least time possible and in the cheapest manner regardless of quality, reputation or long-time use.

One of the bright spots in the picture is the marine laminating program. Most of you are familiar in a general way with the work which has been done in this connection. At the start of the war, construction of wood boats was just about on the same plane that it was during the war of 1812. Perhaps the plane was even a little bit lower because of the scarcity of large dimension timbers in the species required. Fortunately, the groundwork had been laid for a research program that was intended to develop synthetic production of long-length and variously shaped durable timbers. To-day that research and the business built on it should assure an opportunity to participate in the new pleasure boat industry that will arise after the war.

The industry can retain and even secure a firmer grasp on the marine market provided the wood products industry is willing to assume the burden of continuing the research and development that has been conducted on this important project. The principal point to be remembered is that here is an example where through intelligent research the industry as a whole will benefit. and furthermore this advancement has been handled in such a way as not to hinder the volume of war production but to increase it. It is useless, except for historic purposes and as an object lesson, to predict what could have happened in some of the other fields such as truck bodies, office furniture, and refrigerators had we been able to take advantage of the market opportunity for these articles as we did for marine laminating. Had we been able to exploit the opportunity with new products born of research, the picture would have been considerably brighter.

The Problem

Very simply our problem can be stated in the following terms:

1. We need an analysis of the various wood products markets to determine which ones are worth keeping and fighting for and which ones should be discarded as not worth the effort.

2. We need to determine which markets appear to be most critical from the competitive stand-point and therefore need a maximum of research development.

3. We need to find out why we are in danger of losing these markets.

4. We need to set up a program of research and investigation designed to improve the product and fit it for a better competitive position.

Returning again to the wood desk as an example, work is now under way in laboratories to improve it, but before getting out the test tubes it was necessary to find out what's wrong with the present type. A survey disclosed the following: The wood top was too soft; it marred easily, and with use the finish became shoddy. Furthermore, the conventional type of varnish finish cannot be kept clean. In one large government department we were told that the employees preferred metal desks because the janitors washed the writing surfaces every night with water and soap; on the other hand, wood desks were polished with an oily rag usually not too clean. In another department we were told that the feminine employees were prejudiced against wood desks because the splinters from the rough edges ruined their hose. Still others objected to wood desks because the drawers stuck or because of a peculiar idea that a wood desk was not fire resistant and therefore a dangerous place to store papers and a building hazard.

The answer is of course to engineer a new type of wood desk wherein these deficiencies have been removed. It is not an easy task, nor can it be accomplished at the sawmill or at the desk factory. It is a job first of all for the research laboratory. We know how to impregnate wood with various chemicals so that the wood can be relatively stable to dimensional changes, so that it is harder than normal wood, and so that it has other properties such as increased fire resistance, decay resistance, etc. But it is a far cry from the laboratory stage to practical manufacture, especially for such articles as desks and other furniture.

Theoretically, we could make an ideal desk, one that would answer every service requirement and for appearance and utility would shame its nearest competitor. This could be done with present facilities, but in doing so one would have to forget about the cost of manufacture, thereby destroying the balance between price competition and utility value. It is the job of the research organization co-operating with the producers of the material to find some way to do these things without

adding largely to manufacturing costs. In general, it is safe to assume that when anything is done to a piece of wood the cost rises rapidly. Probably the cheapest treatment available for hardening lumber and giving it certain other desired qualities costs at least 6 cents per board foot. Thus an article such as a desk, which contains from 75 to 100 board feet, of treated lumber, would be increased in cost by $4·50 to $6·00.

This increase in cost would be ruinous to stability of "price competition" unless of course the treatment enhanced the desirability of the product to such an extent that the consumer preferred to ignore price. It is intriguing to look at beautiful samples fresh from the laboratory and to speculate on how much certain improvements would enhance the appearance and utility of a product. But too much crystal gazing may cause one to become too enthusiastic to be able to evaluate the difficulties which may be incurred in applying a new process. To develop an improved commodity simply on the basis of increased utility value, regardless of cost, is a poor bet, and the chances are that the manufacturer of competing products would leave no stone unturned to meet technical improvements. Furthermore, he would know beforehand that he would have to obtain improved quality at a cost somewhat less than that of his competitor. In this instance we would be as bad off if not worse than we were before. It might seem that because of these factors the industry has become enmeshed in a hopeless situation. Give the patient the treatment accorded a dying man, a shot of morphine so that he can reach the inevitable end with a minimum of pain.

A Probable Solution

Fortunately, there are ways and means of avoiding the situation just described. It may be done as follows :

1. Utilize by-products in such a way that the profit from their sale will improve cost of production.

2. Change the method of manufacture to such an extent that economy in one phase of manufacture can offset the increased costs in another.

The first method should be thoroughly explored, especially when there is considerable waste in manufacture. For example, in the production of lumber only about one-third of the trée reaches a market. The other two-thirds is thrown away or at least used for boiler fuel. Obviously, if this waste can be sold for a profit, the cost of lumber can be reduced and a certain proportion of these reduced costs can be divided between the producer and the consumer. This is the reason why the Timber Engineering Company is now engaged in trying to establish a wood-sugar industry. It is exactly the same principle on which the meat packers operate and which they advertise by the well-known slogan that the packer saves everything except the "squeal." The lumberman should go even further by saving the "bark."

But getting back to desks, it will of course be vastly helpful if the lumber industry through utilizing waste products can reduce the price of lumber. However, that is a meagre hope and an indirect approach to the solution. It is a solution which will take more time than can be afforded if many of the principal markets are to be retained. Therefore, method number 2 should be studied as the possible cure for the expiring patient. Probably one of the most expensive factors in manufacturing desks or other furniture is the cost of finishing. If a major portion of cost of finishing or even a part of it could be eliminated, the producer would come pretty close to finding a method whereby he could economically treat the wood to give it added qualities of hardness, dimensional stability, fire resistance, etc. Supposing that through this same treatment the producer could colour the wood and then by pressing obtain a sheen finish that is equivalent in appearance to the conventional finish. If this can be accomplished on a commercial scale, we will have surmounted one of the major obstacles in retaining a valuable market.

Wood Products and Production Line

Unfortunately, wood products manufacture has in general not been a straight line, rapid process. Metal objects, such as dishes, automotive paneling, toys, furniture, and caskets, are stamped out of a sheet of steel with one stroke of the press, but a wooden article for similar utility goes through a much slower and more costly process. In many lines of manufacture we must in one way or another overcome this handicap. In some instances this may not be too difficult. For example, a large toy manufacturer was recently faced with a

shortage of steel which he needed for wheels for small wagons and kiddy cars. Because of the shortage of metals he was forced to manufacture wood wheels, but to produce, a wood wheel in the conventional way required sawing, turning, and finishing. Even after these expensive operations were performed, the wheels were not particularly satisfactory but seemed about the best that could be obtained. Since the wheels were of solid lumber, changes in dimension because of variable moisture content conditions caused the wheel to be oval, and because it was economical to use a soft-textured wood the wheels when put into use deteriorated rapidly because of abrasions and splitting. Through new systems of impregnating, this toy manufacturer was able to obtain help. He is now installing some new equipment which will not only put his wheel business on a production basis but will provide a better wheel at lower cost. The new system will be somewhat as follows:

Blanks of wood from which the discs are to be made will be impregnated with a low-cost coloured resin. Discs will then be cut out of the blanks with a disc saw just like mother cut doughnuts with a doughnut cutter. They will then be put into molds in a hot-plate press and stamped into the desired shape. No turning or other operation will be necessary. This has been made possible because the resin impregnated into the piece gives the wood plasticity, permitting it to be shaped under pressure and heat conditions. The manufacturer through this process, if successful, will have accomplished several things:

1. A slow expensive turning, sawing, and sanding operation will have been made over into a straight line rapid-production system where the work will be done in a fraction of the time previously required.

2. By means of the system, colour and a high polish finish will be obtained at small expense.

3. A product will be produced that will have relative dimensional stability under severe conditions of use.

4. Wearing qualities will be improved.

5. The general appearance will be much better because a new and more desirable design can be used without adding too much to the cost.

Another fine example of improvement is the use of glue in laminating. At the beginning of the war all rubber boats, life boats, etc. were equipped with solid wood paddles. Because the wood from which they were made was frequently inadequately dried, or not dried at all, the service results were not uniformly satisfactory. By the use of glue which had been developed in laboratories and by means of technique worked out in pilot plants, this problem was licked, and because of it not only wood products for marine use were generally used but many other kinds of new products not connected with the marine services became possible.

Research Program for the Future

There are literally dozens of organizations anxious to undertake research for the lumber industry, but with few exceptions these organizations require two things:

1. Money to conduct the work.
2. Direction in the type of research needed.

Some of them are competent, well managed, and capable in every way to undertake programs for the industry. They should be encouraged to the fullest extent.

In regard to the two requirements which these organizations need to get them to work, that of obtaining the money is probably the least difficult. There are all sorts of ways for doing it and these methods are so well known by the industry that there is no object in discussing them here. The second condition is more difficult to handle for the following reasons:

1. Most research organizations are not acquainted with the lumber industry's problems and are incapable of recommending what should be done. For this information they must necessarily depend upon their sponsors not only to furnish the funds but to tell them what to do.

2. Many of the potential sponsors, though well informed and perhaps capable of directing a research program, are so busy with affairs of business management that they cannot afford to take on this extra responsibility.

3. In those instances where neither the sponsor nor the research organization is able to take on the responsibility of directing a program, the background and facilities for co-ordinating the research are apt to be lacking. Without such co-ordination there will inevitably be a large amount of duplication and therefore a

waste of funds. As an illustration of this, two universities have been making investigations regarding the practicability of producing cork from bark of trees. Had this work been properly co-ordinated, the results would probably have been obtained as quickly and at half the expense. This is not a criticism of the work of the universities but simply recognition of the fact that one of our most urgent needs is to co-ordinate all types of wood research and to encourage organizations to make use of the knowledge gained by each other.

The solution to the problem is of course to put the direction and co-ordination of research in the hands of the central organization that has facilities to make a speciality of the field.

Two Fields of Wood Research

An outline that mentioned all the needed investigations in the field of wood research would require a volume of more length than permitted here. We can, however, consider a basic program to which the details can be added as needed. In general, wood research may be broken down into two classes :

1. Improvement in lumber and lumber products.

2. Utilization of wastes in the woods and at the mill.

The first would be calculated to improve the quality and utility of lumber and lumber products of the kind usual to sawmills and wood-products operations. The research necessary to do this would be expected to develop new products and new markets. The research to be undertaken would be both physical and chemical. It would probably be necessary to carry on chemical research in utilizing and developing known and new glues, wood impregnation and compregnation processes, dimension stabilizers, fire-resistance controls, decay resistance, method for increasing strength properties, such as hardness, resistance to impact bending, etc. In most instances, regardless of the amount of effort expended to decrease the cost of such processes, it would probably be found that in general the improved products would be more expensive than wood in its natural state.

The second field of research or utilization of woods and mill wastes, if successful, would have two objectives : profitable use of a greater proportion of the tree or log, and reduction in the cost of lumber and lumber products. If, for example, we can obtain a profitable by-product from woods waste, the over-all cost of logging chargeable to lumber may be reduced and the markets for the products extended. Recovery of mill waste for usable and sallable products would tend to reduce the cost of raw materials for the major lumber and timber products.

Which of these fields is the most important to the general welfare of the industry is probably not definitely known, but from the standpoint of the individual lumber or wood-products manufacturer, the importance would depend to a considerable extent on the length of time he expected to be in business. For short-time operators, improvement in lumber and lumber products probably has more appeal. It should also be of much interest to long-time operators who expect to perpetuate their business. The following general outline for the two groups probably sums up the type of research that should be undertaken by the lumber industry.

Improvement in Lumber and Lumber Products

Under Group 1 the factors which are wrong with lumber or lumber products should be given first attention. These in the order of their importance would probably be somewhat as follows :

1. To devise a method whereby relative dimensional stability can be obtained economically. Of all the difficulties in handling wood, probably the inherent characteristic of the material to shrink, swell, warp, and distort is more discouraging to the user than any other factor and therefore more encouraging to competitors seeking to replace lumber markets.

2. To obtain better and more uniform quality in the properties of wood, including strength. Wood to compete with plastics must be made more uniform in quality. It must have other properties which will allow it to be worked and handled as successfully as plastics. To compete with the lighter metals for many purposes, it must have certain increased strength requirements.

3. Fire resistance. Fire-resistant properties for wood, ranging from the high-priced field to the low-priced, rank only slightly less important.

4. Decay resistance. This is less important than the other fields cited but is a factor in determining the use of wood for many purposes. Various species are affected differently. Some

need this protection more than others, but as a rule treatments can and should be developed whereby species generally will benefit. The sapwood of even the most durable species, for example, is not considered stable.

To obtain the greatest value from moderate expenditure in this field, applied research probably offers larger opportunity now than more fundamental research. For example, in the files of the Forest Products Laboratory is a wealth of fundamental research awaiting practical application.

UTILIZATION OF WASTES

The order of importance under Group 2 would probably be something like this:

1. Hydrolysis of wood wastes.
2. Distillation of wood.
3. Use of wood sawdust or wood flour for molding powders, polishing materials, or in other places where mechanically ground wood could be used.
4. Development of wood for fuels.

Hydrolysis of wood is listed as the most important, for at the present time at least it is probably recognized as being the foremost field for breaking down wood and obtaining valuable products therefrom. It is the basis for obtaining sugar which can be made into alcohol, or feeding yeasts, or glycerine, acids of various kinds, motor fuels, substitutes for petroleum, fertilizers, bonding material, etc. Lignin obtained through hydrolysis may have a vast and lucrative field for those who have the courage to develop it. Wood hydrolysis is probably the predominant field in which the largest quantities of mill wastes and eventually wood wastes may be utilized.

—*Journal of Forestry*, Vol. 43, No. 3, dated March, 1945.

VOLUME 72 NUMBER 4

INDIAN FORESTER

APRIL, 1946

SOME AFFORESTATION PROBLEMS IN ORISSA.*

By J. W. Nicholson, C.I.E., I.F.S.

(*Conservator of Forests, Orissa*)

Fixation of shifting sand

Strictly speaking we have done nothing in the line of fixing sand dunes. When the Puri *Casuarina* plantation was first started in 1916 it was thought that it would be necessary to fix the sand dunes with grasses and an attempt was made to do so, but the work proved unnecessary and was discontinued. The original *Casuarina* plantation was gradually extended to an area of 3,350 acres. Various planting distances were tried but 10 by 10 feet was the commonest. In the 1932-33 working plan the distance was reduced to 9 by 9 feet and a low rotation of 12 years was laid down in order that old plantations could be worked over quickly. The working plan visualised that the rotation would eventually be raised to 15 years, but this was an under-estimate as sample plot data indicated that the mean annual increment would certainly not culminate before the 20th year. Under the newly-revised working plan a planting distance of 8 by 8 feet and mechanical thinnings at ages of 6 and 12 years have been prescribed, these prescriptions being based on past experience of growth. We have laid out a number of plots to test optimum planting distance and thinning technique. The problem is not quite as simple as might be assumed as, after *Casuarina* trees reach a diameter of about 10 inches, difficulties of splitting cause a price decrement. Recent successful experiments in charcoal manufacture should lead to fuller utilisation of oversized butt ends.

The original plantation, which is now being extended by a further 1,000 acres, has paid more than 4 per cent, calculated at compound interest, on the capital outlay. This percentage would have been much greater had not some of the earlier technique been faulty and had not certain large scale failures taken place.

The *Casuarina* plantation is traversed by a shallow river bed in which water flows only temporarily during the rainy season. The sand in the river bed is very coarse grained. In the early years repeated attempts to plant up this area all resulted in failure, species other than *Casuarina* being tried. As the river-bed area is extensive we are still making very small scale experiments. Over a moderately extensive area of the plantation various exotics were tried such as *Cassia siamea*, *shisham* (*Dalbergia latifolia*), *Eucalyptus* species, *Albizzia* species, *Melaleuca glaucum*, etc. None of these species has shown any promise. Cashew nut (*Anacardium oxidentale*) has done quite well and, given side shade, *Calophyllum inophyllum*. The revenue from these latter two species has been negligible.

The biggest tragedy occurred through the construction in 1931 of a cut from the Sur Lake through the plantation to the sea by the Public Works Department in order to reduce the inland flood menace. Dying off occurred over large areas of the plantation. Several theories were advanced as to the cause of this dying off but I have personally no doubt that the Sur Lake cut was responsible. On the sand dunes the *Casuarina* were not affected as they develop deep tap roots. On level sand where the water level remains high for many months of the year tap roots are not developed. If there is any general fall in the water table the horizontally spread roots fail to cope with it. In 1936 I decided to take the risk of replanting the areas over which failures had occurred as I believed that young plants would adapt themselves to the lower water table. All went well, but in 1940-41 the P.W.D. deepened

*Paper presented at the 6th Silvicultural Conference, Dehra Dun (1945), on item 6—The Afforestation of Dry and Desert Areas.

the cut and again the same phenomenon occurred in April 1941. I complained to the P.W.D. who sent an officer to investigate conditions. He took water levels and found that the Sur Lake cut had substantially lowered the water table within a mile or so of the cut. We are now being threatened by a further projected deepening of the cut and more calamities are probably in store. In order to maintain the water level in the plantation we tried damming up the river bed. Cyclonic rain washed the dam away but not before it was discovered that the Sur Lake cut had beheaded the river. Damming experiments are still in progress.

The most baffling problem, however, is the inequality of growth on level sands. We can account for some of the difference on the grounds of water level (*N.B.*—There is evidence to show that the waters of the Sur Lake seep through the plantation towards the sea: the nearer the lake the better the growth), but we cannot account for others. Within areas of good growth there are patches of very poor growth and in the later acquired areas the growth is poorer than in those first tackled. An examination of watering holes in the poor areas indicates a yellowish iron-coloured stratum which the *Casuarina* roots seem to dislike penetrating. We have asked for the help of the agricultural department and of the forest research institute in analysing this stratum and the causes of this failure but the replies have not been helpful and we are still as ignorant as we were. The matter is of the greatest importance. We are not only going to extend the present plantation but, under our post-war development programme, it is proposed to establish *Casuarina* plantations elsewhere along the coast wherever there is a shortage of fuel. We do not wish to waste money on buying land which is not the best available for our purpose. Growth on sand dunes is definitely slower than on the level but there is very little variation; the cost of acquisition is lower than that of level ground; and so sand dunes, in my opinion, constitute the safest buy. This is essentially a problem in respect of which we want practical forest research institute help and not sub-Himalayan letters.

Prevention of erosion especially by means of contour trenching

The first contour ridging-cum-trenching in Bihar and Orissa was carried out by myself in a lac host plantation in Palamau division. The plantation was situated on a low hill. Contour ridges starting at the top of the hill were constructed at vertical intervals of about 4 feet and to stabilise them *sabai* grass was later planted on them. The ridges proved most effective as all rain falling on the plantation was held up except for some unavoidable run-off in one corner. There is no doubt but that the plantation benefited from the ridging. A certain conservator of forests was so struck with the idea that he then initiated the much advertised contour trenching experiments at Bamia Buru in Kolhan division. These have been the theme of many a quip in the *Indian Forester* owing to the fantastic claims made by the rain and vapour makers. The experiments were not confined to Bihar. In one forest locality in Orissa a night prowling forest officer still runs the risk of spraining his ankle in trenches cut through solid shale. Personally I have no faith in contour trenching in existing forests, proving of any value, commensurate with the heavy capital and recurring costs involved. On eroded or barren slopes the value is unquestionable, but in my experience the cost is not justifiable unless a particularly valuable crop is to be grown or land is to be reclaimed and loss of soil checked for an agricultural purpose.

BEST TIME FOR THE COLLECTION OF SEED OF *TERMINALIA CHEBULA*.

By Jagdamba Prasad, B.Sc., LL.B., P.F.S.

(*Experimental Assistant Silviculturist, F.R.I., Dehra Dun.*)

Introduction

The best time for collecting seed of forest tree species for artificial regeneration work should be of vital importance to the seed collector, because the planter is the sufferer in the end of mistakes made in this respect.

There is a singular paucity of information on this subject in the forestry literature of almost all countries. In India the study of this question was taken up in the last decade. The work is, however, far from comprehensive. There is thus great need and scope for work, which it is hoped the present note will stimulate.

MADRAS. As stated in the annual silvicultural research report of Madras for 1939-40, para 33, tests were made with seed collected at fortnightly intervals of eleven species: *Acacia leucophlœa*, *Artocarpus hirsuta*, *Cassia fistula*, *Cassia marginata*, *Evodia roxburghiana*, *Hopea parviflora*, *Mesua ferrea*, *Pterocarpus santalinus*, *Swietenia macrophylla*, *Terminalia chebula* and *Terminalia paniculata*. In each case these seed collections covered a period of six weeks to two months. In no case, however, were there any definite variations in germinative capacity throughout the fruiting season.

F.R.I.—Work at Dehra Dun was confined to extensive trials with the seed of *Terminalia chebula*. At last efforts have resulted in eliciting interesting and valuable information with regard to the quality of the seed collected at set intervals.

An account of this work is now being attempted here, in sufficient detail, to indicate the pitfalls and to describe the technique evolved from the investigation.

Experimental Details

The project

In January 1932 CHAMPION drew up the project for experiment No. 79(a), entitled, "The best time for seed collection."

The object of the experiment was to determine the optimum period for certain species, when the seed is available and ripe for immediate sowing.

A sample of the seed, sufficient for five germination tests after cleaning, was to be collected, at fortnightly intervals and germinated under ideal conditions each time.

Only such seed was to be collected as would ordinarily pass as sound ripe seed, as far as possible from the same restricted locality, though not necessarily from the same tree each time, but from such trees as were in fruit.

Either a random sample equally representing several trees was to be used, or seed from several trees was to be collected and tested separately, if quantities and space permitted.

Early experiments

On each of the three dates, 23 II '33, 8 III '33 and 22 III '33, 250 fruits of *Terminalia chebula* were collected and 150 fruits on 7 IV '33. Sowings could not be done until the first week of August 1933, owing to continuous rains.

The fruits of each date of collection were sown alternately, in pairs of lines (25 per line). As there were only 150 fruits for the last date of collection, they sufficed for only six lines (three pairs), the remaining pairs of lines falling due for this date being left blank.

The lines were weeded when necessary and observations were recorded. The percentage of germination was very low, being 1·2, 3·2, 6 and 8, respectively, for the four dates of collection.

Later experiments

The experiment was repeated five times in 1934-35, 1936-37, 1937-38, 1938-39 and 1939-40, the collection of the seed being commenced in December and completed by January and in one case by early February.

The last experiment confirmed the indication of the previous ones, that the dates 6th January and 13th January were preferable, for seed collection.

The first four trials, however, showed very low germinative capacity, 2·4 to 16 per cent, whereas in the last trial it ranged between 10·5 and 56. The former results were apparently vitiated by the far greater masking effect of sowing the seeds with the pulp on. It was accordingly decided to repeat the experiment with depulped seeds in the three following years.

Experiments of 1940-43

Lay-out. Three improvements in the details of the experiment were introduced :

1. Depulped seed was to be used for all the trials.

2. The interval of seed collection was to be shortened to weekly in place of fortnightly collections. It may be remarked, here, that CHAMPION provided for this course in the original project as an alternative.

3. A randomised block layout was to be employed in place of the paired line sowings, in nursery beds, for compactness.

Twelve dates for seed collections were accordingly fixed as follows :—

Table I.—*Dates of weekly collections of seeds of Terminalia chebula.*

1. 11th December.
2. 18th December.
3. 25th December.
4. 1st January.
5. 8th January.
6. 15th January.
7. 22nd January.
8. 29th January.
9. 5th February.
10. 12th February.
11. 19th February.
12. 26th February.

Six nursery beds, 35 feet long and five feet wide each, were used for carrying out the experiment, in the three years. The two beds required for each year's experiment were contiguous and all were subjected to the same routine of soil working.

Each bed was divided into four blocks of twelve lines each, eight inches apart, with a space of 12 inches between the blocks. 25 seeds of each collection were sown in one of the lines, the selection of the line for a particular treatment (date of collection) being decided from random figures in TIPPET'S tables of random numbers, as explained below.

Turning to page IX of *Random Sampling Numbers* by L. H. C. Tippett [Cambric University Press (1927). Price 3*s.* 9*d.*], openi the book haphazardly, we take a series of two-figure numbers: 35, 37, 43, 37, 84, 95, 20, 89, 43, 67, 91. The place for the 12th weekly collection of sowings in the block is selected by dividing the first random number by 12. Thus 35 divided by 12 gives a reminder of 11 and so the collection of the 12th week is to be sown in the 11th line. The place for the 11th weekly collection for sowing is selected by dividing the next random number in our series by 11. The remainder is 4 and so the collection of the 11th week is to be sown in the fourth line. The third number divided by 10 gives 3 as the remainder and the tenth week's collection is marked down for the third line. Similarly the ninth week's collection is marked down for line 1. The next number in our series is 84. This is divided by 8, leaving 4 as the remainder. For the eighth week's collection the line selected is the 7th, as counting is done for existing vacant places. This procedure is followed until we get the complete set for the block, as follows :

Line No.	1	2	3	4	5	6	7	8	9	10	11	12
Treatment	9	3	10	11	6	2	8	7	4	1	12	5

The positions in the remaining blocks were similarly determined, taking a fresh set of random numbers.

The seeds were sown in the second week of May, each year, and the records of germination were maintained, heights of all seedlings being measured up in the cold weather.

Results.

The combined results for the three years are as follows :

Table 2.—*Germination per cent and average height of Terminalia chebula.*

Treatments	1	2	3	4	5	6	7	8	9	10	11	12
Germination per cent. ..	60	47	44	55	53	61	40	44	45	33	26	32
Average height in inches	6·5	6	6·3	6·1	6	6·1	5·9	6·6	6·8	6	6·1	5·9

Analysis of the data.—Here the more important factor, obviously, is the germination per cent. In the analysis we have to make allowances for the interaction of treatments, seasons and the replications (called blocks). The results of the statistical analysis are shown below.

Table 3.—*Analysis of variance of germination counts of* 12 *weeks' seed collections of Terminalia chebula for the three years* 1940-41 *to* 1942-43.

Source of variation	Degrees of freedom	Sums of squares	Mean sum of squares	Observed	From tables 5%	From tables 1%
Blocks	7	212·4	30·34	4·617	2·05	2·73
Seasons	2	670·1	335·05	50·997	3·04	4·71
Treatments	11	2046·7	186·06	28·320	1·83	2·34
Interactions:						
Blocks × seasons	14	268·8	19·20	2·922	1·74	1·17
Blocks × treatments	77	477·1	6·20	0·944	1·35	1·53
Seasons × treatments	22	1590·1	7·22	1·099	1·62	1·97
Error	154	1012·3				
Total	287	6277·5				

The treatments have caused highly significant variation in germination. The critical value for determining the significance of any two treatments (dates of seed collection in this case) is 1·45 at 5% and 1·91 at 1%. These figures relate to the number of seeds used in each line, which was 25. As the figures in Table 2 are percentages, or 4 times 25, the critical values may be taken as 5·8 or 6 and 7·64 or 8 percent. respectively, at 5% and 1% levels.

From Table 2, we see that the mean of the sixth treatment exceeds all but Nos. 1 and 4, by the higher critical value. It exceeds No. 4 by the lower critical value at 5%. Proceeding in this manner we get a phalanx of comparative values for the treatments, which we appraise by the two critical values set down, as the yard-stick.

Conclusion

From a study of the mean values and the comparisons provided, it is found that the safest period is the first fortnight of January, for the collection of the seed of *Terminalia chebula*.

The following remarks from *Indian Forest Leaflet* No. 75—1945 (Chemistry and Minor Forest Products) indicate the probable correlation between high tannin content and optimal germinative capacity in the case of this species:

"PURAN SINGH'S investigations show that from the point of view of tannin content, the time of collection is important, and that the best myrobalan is collected in January anywhere in India, later collection being less good and earlier collections much inferior."

BETTER UTILIZATION OF FOREST GRASSLANDS IN BOMBAY PROVINCE. *

By L. S. S. Kumar, M.Sc. (Lond.), A.R.C. S., D.I.C.

(*Economic Botanist to the Government of Bombay*)

The improvement of livestock is intimately bound up with the better utilization of grasslands and grazing areas, as the majority of Indian livestock get most of their food during many months of the year from this source. As very large areas of grasslands are to be found in forests and are controlled by the forest authorities it is in the fitness of things that the question of the management and better utilization of these grazing areas forms an item on the agenda of this conference.

According to the present practice the management of grazing areas in forests depends entirely on the types of trees composing the vegetation of the pastures. The best care is taken of those grasslands which contain useful timber trees. The forest grasslands are classified into (*a*) which are completely closed to grazing, (*b*) in which cutting of grass alone is permitted, (*c*) which are opened to grazing after a definite period of closure and (*d*) which are open to grazing all the year round. The vegetation in pastures completely closed to grazing all the year round and those in which cutting of herbage alone is allowed, is always the best. In pastures which are opened to grazing after a definite period of closure, the vegetation is quickly denuded because of excessive and continuous grazing soon after those protected areas are thrown open to grazing. So whatever improvement was gained in affording protection to the vegetation during periods of closure is lost in a couple of years when unrestricted grazing is allowed. In pastures open to grazing all the year round, the condition is at its worst perpetually. There is a limit to which any grassland area can supply feed for livestock and when this limit is disregarded and heavy, continuous and unregulated grazing is practised the natural vegetation begins to suffer and to deteriorate both in quantity and quality.

The principles underlying the management of grasslands is to prevent indiscriminate grazing. As already pointed out imposing complete closure or allowing only cutting of herbage without allowing grazing are some of the methods of protecting grasslands from being damaged. But this is practicable only in limited areas or areas inaccessible to cattle. To introduce such a practice close to villages which maintain a large number of cattle is undesirable. Where complete closure is enforced, it causes considerable grievance and alienates the villagers from government departments which are striving for the welfare and uplift of the villagers themselves. Grazing in itself is not inimical or damaging to grasslands or pastures. It is only when it is carried out indiscriminately and incessantly that grasslands become damaged. On the contrary, controlled grazing if introduced improves the grasslands, as stock nitrogen becomes available by animals being allowed to graze and wander over the pastures. In those areas where grazing is to be permitted, it should be controlled and be of the rotational or intermittent types. The principle underlying rotational grazing is that every pasture or part of a pasture is given a period of rest to recuperate from the effect of grazing and is allowed time for a second flush of vegetation to come up.

The best method of carrying out rotational grazing is that which combines rotation in time and space. By dividing the grazing area into several compartments and grazing them one at a time introduces rotation in space. By commencing grazing with different compartments in different successive seasons rotation in time is achieved. Further, by limiting the grazing in pastures to that period during which edible grass in sufficient quantity is available and closing it during such periods when the vegetation has dried down, the pasture can be maintained in good condition and gradual improvement in the vegetation brought about. But under no circumstances grazing is to be allowed until the grass has grown to sufficient height so that it will not be injured either by browsing or trampling. Otherwise many of the annuals

*Paper presented at the 6th Silvicultural Conference, Dehra Dun (1945), in item 6—The Afforestation of Dry and Desert Areas, communicated by the Silviculturist, Bombay.

which are delicate and have not become strongly rooted will be destroyed by an early commencement of grazing.

In order to explain this method of controlled or rotational grazing, an experiment conducted by the economic botanist's section of the Bombay agricultural department may be described.

At Bhamburda, near Poona, a small grazing *kuran*, situated on the lower slopes of a hill was taken over by the agricultural department for experimental work towards its improvement. The soil varied in depth and character in this area. There were few trees upon it and, as the *kuran* had been, for many years, subject to indiscriminate grazing by the cattle of neighbouring villagers, the grass covering was poor and scanty. The total area of grassland utilized for experimental purposes was 40 acres. To begin with, the area was bunded wlth small contour embankments which were largely constructed with the small stones, etc., scattered across its surface. All small gullies were also blocked with "plugs" or embankments. The area was then divided with fencing into 4 blocks of 10 acres each. Each year, only three blocks, *i.e.* 30 acres, were opened for grazing, the other block of 10 acres being reserved for re-seeding followed by grass cutting and no animals were allowed to graze upon it. Thus each year, a separate block received no grazing until after the grass had been cut.

Twenty cattle were used for grazing purposes in this experimental area and each of the three blocks of 10 acres allotted for grazing was opened to these cattle in rotation at fortnightly intervals from the 16th July to the 15th August and, at monthly intervals from 16th August to the 16th December. The other block of 10 acres was only opened for grazing once, *i.e.* for one month after the cutting of the grass had been done and second growth was coming up, *i.e.*, from 16th December to 15th January. The actual programme of grazing carried out is given below:

Period		*Block*
July 16, 1928 to July 31, 1938	..	III
Aug. 1, 1928 to Aug. 15, 1938	..	II
Aug. 16, 1928 to Sept. 15, 1938	..	IV
Sept. 16, 1928 to Oct. 15, 1938	..	III
Oct. 16, 1928 to Nov. 15, 1938	..	II
Nov. 16, 1928 to Dec. 15, 1938	..	IV
Dec. 16, 1928 to Jan. 15, 1929	..	I (second growth after cutting)
Jan. 16, 1929 to Feb. 10, 1929	..	III
Feb. 11, 1929 to Feb. 28, 1929	..	II

The block containing the coarsest, tussoky grasses, *i.e.* block III, was opened first for grazing. Block IV, which was the most inferior block, was grazed last in order to give the vegetation in this block time to grow well and send down roots so that it would not get spoiled further by trampling and grazing early in the season. Block I was not opened for grazing at all until the grass had been cut and stored for hay after which cattle were admitted to graze (from 16th December to 15th January) on the second growth. What was the result of this system of grazing in rotational blocks? At the end of 4 years, *i.e.* when only one complete rotation was finished, the plant population, *i.e.*, the number of plants found on a unit of ground, had increased almost threefold, the tussocks or clumps of grass had developed to three times their original size and the yield of grass had increased from 3,000 lbs. per acre to 4,000 lbs. per acre. The original poor grazing land was rapidly improving into good grassland. Better quality vegetation, with a higher percentage of leguminous plants, had sprung up. Tree and bush growth had increased and, in general, a small section of grassland under the experiment was quickly developing from barren and scantily-covered slope into a well-covered and useful fodder-growing unit, which could support more cattle than previously and afford them a larger quantity of more nutritious feed.

The advantages to be gained by such a system of rotational grazing in compartments may be summarised as follows:

(1) The restriction of animals to limited areas (compartments) enables intensive grazing and avoids waste.

(2) Intermittent grazing provides rest by turns to parts where additional growth of grass takes place during the same season and thus increases the total yield.

(3) Controlling and allowing grazing in only such places where the grass had made sufficient growth to withstand treading, prevents injury and death of plants in their early and most susceptible stage of growth.

(4) The grazing of successive fresh growth by cattle is beneficial since the grass in its early stages of growth contains more nutrition than while mature.

(5) Rotational grazing prolongs the period of grazing as compared with uncontrolled grazing.

(6) In forest grasslands, controlled grazing protects seedlings of forest trees from damage by cattle, because of the sufficiency of other feed available.

(7) By protecting the grass cover, the erosion of soil and denudation of land is effectively prevented.

(8) Controlled grazing results in an increase in the carrying capacity due to increase in yield of grass. Grazing lands which at present can barely provide feed for one animal per 4 acres could, in a short period of time, be converted into good grasslands carrying one animal per 2 to $2\frac{1}{2}$ acres, in addition to providing annually a large quantity of grass or hay as reserve rations of fodder during the period of the year when no grazing is available.

Carrying capacity.—It has been the practice hitherto to allow unlimited number of cattle to graze without regard to whether feed sufficient for all is available in the area or not. This has been one of the causes of the deterioration of grass *kurans* ; hence without limiting the number of cattle, improvement of grasslands cannot be affected. The limiting of cattle will depend on the "carrying capacity" of the grazing area. By "carrying capacity" is meant the number of animals that could be maintained on a given grazing area by providing them with sufficient grazing to keep them in good condition during a season. The number would depend on the condition of vegetation of the *kuran* which in its turn is influenced by rainfall of the area. Thus an area of good grassland in heavy rainfall tract can support more animals than an equal area of poor grassland in low rainfall tract. After years of experience, it is now found that to provide enough feed during the season for one animal in the different rainfall tracts, the areas shown in the table below would be required :

Rainfall of the area in inches		Acres per animal.
Above 100	..	$\frac{1}{2}$ to $\frac{3}{4}$
Between 50 and 75	..	1 to $1\frac{1}{2}$
Between 35 and 50	..	2 to $2\frac{1}{2}$
Between 25 and 35	..	3 to 4
Below 20	..	4 to 5

In conclusion, it may be suggested that immediate steps should be taken to stop indiscriminate grazing which has been the cause of thousands of acres of forest grassland being reduced to such a condition of deterioration that the top soil has all been denuded exposing the layers of rock beneath. The effectiveness and advantages of rotational grazing have been conclusively proved and it is high time the various forest departments adopted this system for the grasslands under their control on a large scale.*

**Note by the central silviculturist.*—Rotational and periodic grazing have been practised in several provinces for many years.

THE CONSTITUTION OF THE LAND MANAGEMENT CIRCLE, UNITED PROVINCES

BY M. D. CHATURVEDI, B.Sc. (Oxon.), I.F.S.

(*Conservator of Forests*)

SUMMARY.—Besides providing technical assistance to private owners in the rehabilitation of their woodland hacked about during the war, the Land Management Circle of the Forest Department, U. P., as constituted on November 1, 1945, envisages the economic utilization of all state lands such as those under railways, roads and canals. In addition, it aims at the progressive acquisition of a million acres of wastelands during the next 10 years for the establishment of fuel and fodder reserves, improvement of grazing grounds and the creation of protective belts to arrest erosion. The elasticity of the scheme which can be expanded as funds permit, the provision for the employment of demobilized army personnel and the integrated utilization of lands to cope with the increasing pressure of population are some of its features which commend themselves.

The physical features of the United Provinces suggest the following three natural divisions:

i. The Himalayan tract

ii. The Central India plateau

iii. The Gangetic basin.

The configuration of the Himalayan tract and the C. I. plateau is not conducive to extensive cultivation. These regions are, therefore, sparsely populated and do not call for immediate attention. In the Gangetic basin, where deep alluvium supports extensive cultivation, the pressure of ever-increasing population demands a well-balanced utilization of lands whose analysis reveals the following composition:

		Milacres.*	*Percentage.*
I. CULTIVATION.—			
(*a*) Under cultivation	..	32,140	65·7
(*b*) Current fallows ..	..	1,589	3·3
(*c*) Old fallows ..	..	313	0·6
Total	..	34,042	69.6
II. HABITATION.—			
(*a*) Sites, buildings, etc. } (*b*) Communications }	..	1,666	3·4
(*c*) Graveyards ..	..	29	..
Total	..	1,695	3·4
III. WATERS.—			
(*a*) Rivers, streams, *nalas*	..	Details not available	
(*b*) Canals, lakes, ponds	..		
(*c*) Marshes ..	..		
Total	..	2,302	4·7
IV. TREELANDS.—			
(*a*) Groves ..	..	1,282	2·6
(*b*) State forests ..	..	1,106	2·3
(*c*) Private woods & grasslands		5,663	11·6
Total	..	8,051	16·5
V. WASTELANDS.—			
(*a*) Ravines (estimated)	..	500	1·0
(*b*) Saline soils, *usar*	..	1,942	4·0
(*c*) Sandy soils, *bhurs* (estimated)		100	0·2
(*d*) Bare rocks, Raukar outcrops		?	?
(*e*) Unclassed ..	..	272	0·6
Total	..	2,814	5·8
Grand Total	..	**48,904**	**100**

2. The above classification has been adopted in preference to the one in use in the land records department which mainly concerns itself with whether an area is cultivated, culturable or barren. Thus, the village records continue to regard groves, grazing grounds and treelands which have never been known to be tilled as "culturable." The very nomenclature adopted suggests possibilities of the extension of cultivation where none exists. Similarly, plantations along canal banks, roadside avenues, railway lands and town sites are returned year after year as "barren."

3. It will be seen that the proportion of systematically managed state forests is only about 2·3 per cent. of the total area of this region, which, for a predominantly agricultural and tropical region like the Gangetic basin, is dangerously low.† The mal-distribution

*A convenient term coined to stand for 1,000 acres. Figures given above have been corrected up to June 30, 1944.

†The proportion of forests in some of the European countries which enjoy a temperate climate and are comparatively less dependent on agriculture is as under:—

	Percentage of total land area.		*Percentage of total land area.*
Finland	74	Norway	21
Sweden	55	Italy	20
Russia (European)	44	Greece	19
Austria	38	France	19
Czechoslovakia	34	Belgium	18
Latvia	27	Spain	14
German (Reich)	24	Hungary	13
Roumania	24	Denmark	9
Switzerland	23	Netherlands	8
Poland	23	Great Britain	6
Portugal	22	Gangetic Basin	2

of these forests, which are confined, in the main, to the inhospitable tracts at the foot of the Himalayas, further aggravates the situation by rendering their produce unavailable in the densely populated rural areas beyond a certain economic lead. Due to lack of firewood, the cultivator in this region is compelled to burn (*vide* Fig. II, plate 5). about half of his farmyard manure which has been estimated to amount to 50 million tons per annum. The loss occasioned by this evil practice means a sacrifice of what would virtually amount to an increase of about 15 per cent. over current crop production. In a region where 70 per cent. of the area is under cultivation, which incidentally is the highest record in the world, further extension of cultivation must be viewed with the gravest concern if the agronomical balance between cultivation, habitation, treelands and grazing grounds is not to be permitted to deteriorate further. The return of farmyard manure from village hearths to fields and improvement of grazing are vital factors in the rural economy of this tract. The formation of fuel and fodder reserves constitutes, therefore, an important plank of the programme of land management. From experience gained elsewhere, the target figure for treelands in the Gangetic basin should be at least 25 per cent. of its total area.

4. A review of the possibilities of the creation of village fuel and fodder reserves in various types of lands is given below:

I. Cultivation

Lands set apart for cultivation merit particular attention from the point of view of supplementing fuel and timber resources of this region. Now that the tenant has been given proprietary rights in trees grown on his own holding, he could do his bit by planting up a couple of *babul* (*Acacia arabica*) trees on each acre of his holding. Being a deep-rooted species, *babul* does not compete for nutrition in the upper layers of soil which support agricultural crops. It provides excellent fodder, fuel, tan bark and timber. Above all, its attenuated leaf surface does not shade crops enough to affect production materially. Pruning of branches to a height equivalent to the radius of the crown and reduction of leaf surface to provide fodder for cattle further reduce shade. To compel the cultivator to set apart a portion of his land for fuel and fodder production is to attempt the impossible. It is easier for him to learn to face the sacrifice involved, if any, in the shading of his crops by widely scattered *babul* trees on his holding. An average of 2 trees per acre would mean 68 million trees on the land ear-marked for cultivation or the equivalent of 2 million acres of *babul* plantations with 34 trees to an acre. An area which corresponds to the pattern described above has been under observation for some years in the Bareilly district. The fact that this idea has caught on and spread during the last 15 years is proof positive of its having carried conviction to the hardest of all practical realists, *viz.*, the cultivator. Before giving effect to this proposal on a large scale it is proposed to test it further in collaboration with the department of agriculture.

II. Habitation

Lands grouped under this head provide ideal opportunities for planting trees. Roadside avenues and railway lands, account for an area amounting to about 290 milacres which could be planted up with fruit, timber and fuel trees. Similar opportunities exist on village sites, threshing floors, camping grounds, compounds of public buildings and *nazul* lands.

III. Water

Canal banks at present classed as "under water" will provide plantations, equivalent to 75 milacres.

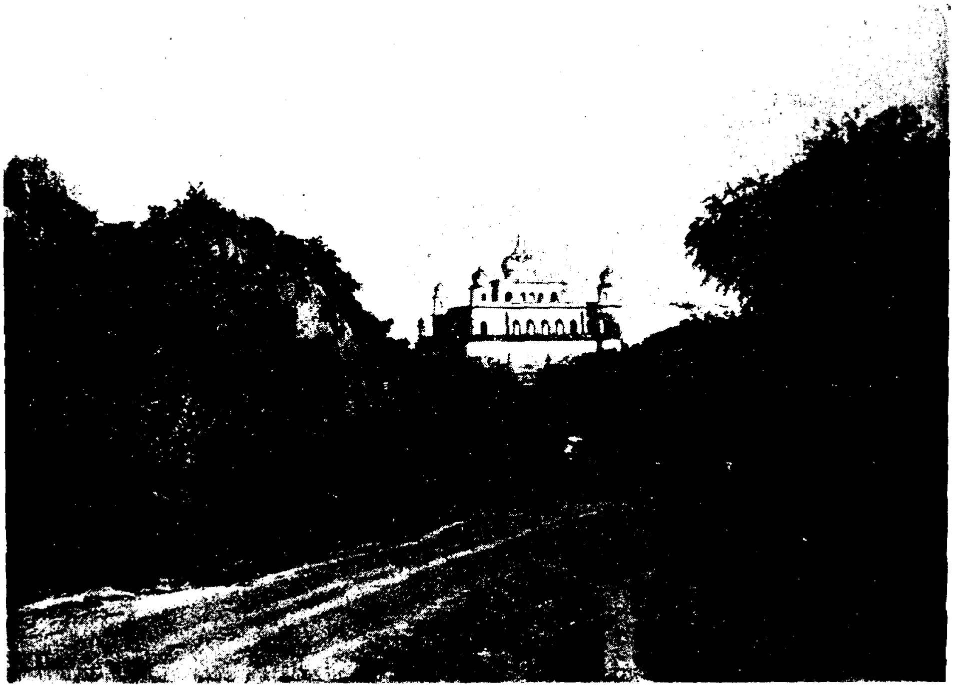
IV. Treelands

Of these, groves which have been hacked about during the war, need renovation. Private woodlands similarly need rehabilitation (*vide* Fig. I, plate 6).

V. Wastelands

Ravines along the banks of the Jamna (Fig. II, plate 6), the Gomti, the Sai and lesser streams account for half a million acres of land where adoption of protective measures to prevent erosion would yield tangible dividends. Saline soils (*usar*) account for 2 million acres which can be made to yield a fair amount of grazing by a simple rotational closure to cattle during the rains. Milder types of *usar* support scattered tree growth where roots can negotiate the kanker pans below. Better types of sandy (*bhur*) soils have already responded to attempts made at afforesting them in the Rohilkhand division.

Fig. I



The Tixi Temple amidst ravines at Etawah.

Fig. II

Dung fuel for village hearths

Fig. I

What a private forest looks like near Fyzabad.

Fig. II

The Jumna's ravines with Etawah on the sky line.

5. The forest department, which was constituted in these provinces in the early sixties of the last century for the management of state forests, has concerned itself in addition to its normal duties, with various aspects of the problems outlined above and a lot of valuable information has been collected during the last 75 years. Attention first came to be focussed on the reclamation of the Jamna ravines in 1912 when the afforestation division was formed to control the erosion along the banks of the Jamna. The next 25 years witnessed systematic research on the treatment of various types of wastelands such as *bhurs* (sandy soils) and *usar* (saline soils). In 1938, a forest development division was formed which has been largely responsible for the creation of fuel and fodder reserves on private wastelands of various types and reclamation of denuded lands.

6. The creation of the Land Management circle in the forest department, U.P., on November 1, 1945, represents the natural sequel to the ever-increasing activities of the afforestation and development divisions. The circle, constituted as at present, comprises the following 4 divisions :

Division	Headquarters	Districts	Area in sq. miles
1. Northern Doab ..	Meerut	1. Saharanpur. 2. Meerut. 3. Bulandshahr. 4. Aligarh. 5. Muzaffarnagar. 6. Muttra. 7. Agra ..	13,276
2. Southern Doab ..	Etawah	1. Etah 2. Ferrukhabad. 3. Mainpuri. 4. Etawah. 5. Cawnpore. 6. Jalaun. 7. Fatehpur. ..	12,293
3. Rohilkhand ..	Bareilly ..	1. Bareilly. 2. Bijnor. 3. Budaun. 4. Moradabad. 5. Shahjehanpur. 6. Pilibhit ..	10,865
4. Oudh	Lucknow ..	1. Sitapur. 2. Lucknow. 3. Unao. 4. Rae Bareli. 5. Partabgarh. 6. Sultanpur. 7. Fyzabad. 8. Bara Banki. ..	13,298
	Total ..	28 districts	49,732

The existing afforestation and forest development divisions have been absorbed in the organisation outlined above which covers an area of about 50,000 sq. miles out of a total area of the 106,247 sq. miles.

7. Apart from tendering expert advice to private owners in the rehabilitation of their woodlands it is proposed to acquire about a million acres for purposes of the creation of village fuel and fodder reserves in the next 10 years. The activities of the circle for the next 5 years will include :

1. Afforestation of state lands such as :

(*a*) Canal banks
(*b*) Roadside avenues
(*c*) Camping grounds
(*d*) Compounds of public buildings
(*e*) Railway lands
(*f*) Acquired lands
(*g*) *Nazul* lands
(*h*) Lands belonging to public bodies such as improvement trusts, municipalities, etc.

2. Creation of small village plantations in all districts where tree growth is at present deficient.
3. Control of erosion, reclamation of ravines and other denuded areas.
4. Utilization of *usar* (saline) and bhur (sandy) soils.
5. Tendering advice on the management of:
   (a) Court of wards lands
   (b) Lands belonging to *zamindars* and tenants
   (c) Groves.

MANAGEMENT AND IMPROVEMENT OF GRAZING IN WASTE LANDS OF THE PUNJAB. *

BY I. D. MAHENDRU, P.F.S.

(*Silviculturist, Punjab*)

(A small scale grassland survey carried out in 1944 in the low hills of the Kangra district near Nurpur elevation 1,450-2,000 ft.)

A small scale survey was made in 1944 of grassland types near Nurpur about 15 miles from Pathankot along the metalled road to Kangra. The area surveyed represents a habitat intermediate between that of *Saccharum munja* in the plains and *Eulaliopsis binata* in the hills. Within the limits of the town committee of Nurpur, two dozen grasses, mostly annuals, are met with in the monsoon and within the extended limits of 5 mile radius which covers two Kangra forest societies as well as other lands, some 90 grasses. From Nurpur nine important paths radiate in different directions and with a few miles along these paths are found different grasses comprising a number of species which grow under widely different conditions in the hills as well as plains. Ubiquitous among these are *Cynodon dactylon* and *Imperata cylindrica*.

I. ARABLE LAND

Classification of arable land.—The whole of the arable land can be classed into one of the three main types, *kukreli*, *dhani* and *khadini*, according to the main agricultural crop raised. The *kukreli* and *dhani* lands are devoted mainly to the production of cereals with fodder only as a subsidiary crop and of relatively minor importance. The *khadini* fields are primarily meant for the production of natural fodder grasses under simple closure from the summer rains to December when the crop is harvested.

Grasses on different types of arable land

1. *Kukreli fields.*—The word *kukreli* is derived from *kukri* meaning ear of maize referring to the chief crop raised; wheat, barley, oats, millet, gram., *til* (*Sesamum indicum*), *mash* (*Phaseolus radiatus*) and *rong* (*Cajanus indicus*) being only subsidiary crops. The summer fallows subsequently sown to winter crops are often used for rasing temporary crop of grasses, practically all annuals and rarely perennials *Cynodon dactylon* and *Sorghum halepense.* Grasses typical of these fields are *Digitaria marginata*, *Eragrostis* spp., *Echinochloa colonum* (small variety), *Dactyloctenium aegyptieum*, *Brachiaria ramosa*, *Brachiaria reptans*, *Sataria glunca*, *Alloteropsis cimicina*, *Cynodon dactylon*, and *Sorghum halepense*. On flat *wats* (boundary embankments) of the fields, *Rotboellis exaltata*, *Heteropogon contortus*, *Cymbopogon martini* and on sloping ground *Chrysopogon montanus* are the characteristic species.

2. *Dhani Fields.*—The word *dhani* is derived from the word *dhan* meaning rice, the fields being almost exclusively under rice. *Dhani* land can be further sub-divided into two different sub-classes on the basis of grasses growing on *wats* of fields. Grasses which grow as weeds in rice crops are identical in both the sub-classes, but different on the *wats* of fields which are subject to varying degrees of soil moisture. The "weed' grasses are *Echinochloa colonum* (big variety) and *Ischaemum rugosum*, while the *wat* grasses are *Imperata cylindrica*, *Saccharum spontaneum*, *Coix*

*Paper presented at the 6th Silvicultural Conference, Dehra Dun (1945), on item 6—Afforestation of Dry and Desert Areas.

gigantea, *Phragmites karka* and *Mnesithea laevis* (*matku*), *Cypress* spp. on wet *wats*; and *Imperata cylindrica*, *Vetiveria zizanoides*, *Mnesithea laevis* (*bekwan* and *matku*) *Bothriooaloa intermedia*, *Dichanthium annulatum* and *Digitaria ternata* or relatively dry *wats*.

3. *Khadini fields.*—The word *khadini* is referrable to *khad* or *nallah* (hill stream), that is rugged land least suitable for cultivation. *Khadini* fields are chiefly allotted to fodder production, and are closed to grazing from July to the end of December, sometimes over January. Harvesting is not done till November or December, although this involves loss of nutrients. The following advantages are, however, claimed for late cutting:

(*i*) Natural reseeding of grasses in the stand.

(*ii*) Avoiding the collection of awned fruit of *Heteropogon contortus* which forms an important constituent of the stand particularly on the flat bits.

(*iii*) Keeping all available labour on the more important work on rice field during the earlier months.

On these fields grasses vary with their proximity to habitation, elevation, etc. On fields close to habitation, and subject to unrestricted grazing, *Bothriochloa pertusa* is the predominant species with a little *Chrysopogon montanus* and *Heteropogon contortus* upto about 1,700 ft. elevation.

Above 1,700 ft. and away from habitation the fields are covered with *Heteropogon contortus* and *Chrysopogon montanus*. The former species spreads on flat bits, while the latter prefers sloping hillsides and well-drained situations. *Cymbopogon nartini* occurs here and there and *Arundinella nepalensis* is very common in bushes and hedges. Sometimes *Themeda anathera* and *Apluda aristata* are found mixed near bushes. Such fields are common near Bodh, Khushnagar and Kharian in the Nurpur tahsil.

Of special interest is a large area near village Baldon, elevation about 1,800 ft., slope gentle, aspect N. W., soil sandy loam which is reserved for the production of fodder grasses. This is the only field on the outskirts of Nurpur where *Capillipedium parviflorum* is found mixed with other grasses, *Heteropogon contortus*, *Mnesithea laevis*, *Chrysopogon montanus* and *Dishanthium annulatum* in the open, *Imperata cylindrica* in moist places, *Themeda anathera Arundinella nepalensis Sorghum nitidum* in bushes. The upper limit of spread of *Capillipedium* touches about 5,000 feet, or, say Dharmasala.

II. Pasture Lands

Classification of pastures.—From the base of hills between 1,450 ft. and 2,000 ft. elevation, leaving out *nallahs* characterised by the growth of *Saccharum spontaneum*, pasture lands can be classified into three chief types with dominant species, *viz.*, (1) *Bothriochloa pertusa*, (2) *Chrysopogon montanus* and (3) *Themeda anathera*. All the three types occur also at higher altitudes and can be recognised as distinct communities, although there is often considerable overlapping.

(i) Bothriochletum pastures

In this type *Bothriochloa pertusa* is the dominant species with *Sporobolus diander* and *Cynodon dactylon* as associates. The former is an annual and the latter a perennial. On shallow soils forming a thin mantle over rocks *Sporobolus diander* appears in the monsoon, seeds about the end of August and completes its life cycle before the end of September. In moister situations, *Cynodon dactylon* gets the better of *Bothriochloa pertusa*, the spread being especially marked on flat ground. Both the species stand heavy grazing, and trampling by animals, in fact there is marked vegetative spread through runners, particularly in the case of *Bothriochloa pertusa*. On the other hand, while *Cynodon dactylon* can stand the kicking pressure of human feet, while *Bothriochloa pertusa* cannot so that *Cynodon dactylon* succeeds in usurping well-trodden paths across these areas. *Bothriochletum* pastures often lie quite close to habitation and are subject to untrenched grazing throughout the year, survival of *Bothriochloa* due to its peculiar tendency of throwing out numerous prostrate shoots rooting at nodes when grazed or mown. This grass is valuable as a soil binder, one of the best fodders and greedily eaten by cattle. Trees and shrubs which cannot stand heavy grazing disappear from areas near villages. *Adhatoda*, *Carissa* and *Dodonaea*, bushes are however met with but even these are sparse and stunted in growth. It is significant that

Bothriochloa pertusa remains away from the bushes in which clumps of *Chrysopogon montanus* and *Apluda aristata sathren*) often come up. The thorny *Carissa* affords protection to these grasses which otherwise have a poor chance even in the bushes of *Adhatoda viscosa* and *dodonaea viscosa*. Sometimes *Chloris incompleta* is also seen in bushes at the bottom of the hills.

Further observations show that under conditions of prolonged closure *Bothriochloa pertusa* gives way to *Chrysopogon montanus* and *Heteropogon contortus*, the former replaces it on the sloping ground and the latter on flats. In the closed areas *Bothriochloa pertusa* ceases to throw out its characteristic geniculate shoots and becomes stalky, so that conditions become more favourable for the spread of *Chrysopogon montanus* and *Heteropogon contortus*. Moreover, natural seedlings of *Bothriochloa pertusa* are tender and easily suppressed by *Chrysopogon montabus* and *Heteropogon contortus* which grow in thick clumps. This explains the retrogression of *Bothriochletum* pasture to lower level with *Chrysopogon montanus* and *Heteropogon contortus* as dominants.

(2) Chrysopogonetum pastures

As already stated *Chrysopogon montanus* grows in *Bothriochchletum* pastures under the shelter of bushes *Chrysopogentum* pastures are characteristic of hill slopes from 1500, upwards in situations subject to relatively less trampling than *Bothriochletum* pastures which prefer moist soils. With the increase in the degree of hill slopes, *Chrysopogon montanus* leaves the shelter of bushes where its place is taken by *Themeda anathera*. *Heteropogon contortus* is the chief associate of *Chrysopogon montanus* especially on inferior soils; its natural spread is helped by its fruit which is disliked by the cattle. *Chrysopogonetum* pastures are distributed over a vast range owing to light wind borne seed of *Chrysopogon mantanus*. In regard to tolerance for shade *Themeda anathera*, *Chrysopogon montanus* and *Heteropogon contortus* occur in descending order.

Heteropogon contortus often forms under suitable conditions a sub-community of its own within the limits of *Chrysopogonatum*.

To determine the relative frequency of constituent grasses in *Chrysopogonetum* pastures a quadrat (10ft. ×10 ft.) was laid out in an exposed situation in closed area, elevation 1,950 ft., slope about 45°, aspect eastern, and soil sandy loam. The surround consisted of scrub, *Carissa spinarum*, *Adhatoda vasica*, *Flacourtia ramontchi*, *Anogeissus latifolia*, *Albizzia* spp., *Nyctanthis*, *Woodfordia* and *Lannea grandis*. Density of the grass stand was estimated at 0.85. The result of counts was as under :

Species.	No. of clumps.	Average height. in feet.
Chrysopogon mantanus ..	44	3½
Heteropogon contortus ..	20	3
Themeda anathera ..	2	4

Under shelter frequency of *Themeda anathera* (*lunji*) was strikingly greater and on flatter bits *Heteropogon contortus* was more prominent. On exposed sloping hillsides *Chrysopogon montanua* forms a major constituent of the stand, in spite of selective feeding by cattle on account of its palatability and nutritiveness.

(3) Themedatum

It has already been mentioned above that in *Bothriochletum* pastures, *Chrysopogon montanus* emerged from bushes on exposed situations. Further, on sloping ground *Bothriochloa pertusa* disappeared and *Chrysopogon montanus* emerged from the shelter of bushes and its place was taken by *Themeda anathera*. Similarly, *Themeda anathera* pushes out in the open with increase in the intensity of overhead shade. Therefore in well-protected areas thickly overgrown with bushes and trees resulting in heavy shade, *Themeda anathera* appears in abundance in the interspaces or under light cover.

In the Kalakh reserved forest, while there is hardly any grass under heavy shade of bushes, there is a thick stand of *Themeda anathera* under the light shade of trees and bushes, and *Chrysopogon montanus* is thinly scattered and under unfavourable conditions even disappears. A quadrat (10 ft. × 10 ft.) was marked under the shade of *Anogrissus latifolia*, 40 ft.—45 ft. in height, canopy thicker towards the sunny side (south) vegetation scattered bushes of *Carissa* and elevation of 1,950 ft. The result of counts is as under :

Species.	No. of clumps.	Average height in feet.
Themeda anathera ..	49	4¼
Chrysopogon montanus ..	39	3
Heteropogon contortus ..	2	2½

Density of the crop was approximately 0·9.

To summarise the results deep shade of trees and shrubs is inimical to *Themeda anathera* and even light shade to *Chrysopogon montanus*. The thicker the shade the less the production of both these species. This is of special significance in the management of grazing as unduly long closure may result in the deterioration of grasses instead of improving them.

EXTRACTS

EROSION AND WATER SUPPLIES.*

BY E. P. STEBBING, M.A., F.L.S., F.Z.S.,

Professor of Forestry, University of Edinburgh.

LORD HAILEY, G.C.S.I., G.C.M.G., G.C.I.E., in *the Chair.*

THE CHAIRMAN:

Whatever may be the scientific progress of the world and whatever substitutes science may find for the primary products of agriculture, in the long run the prosperity and contentment of a great mass of the world's people will depend upon the correct utilisation of the land. That problem is one in which we, in the British Commonwealth, who control such large spaces of the world devoted to primary production, are predominantly interested.

It is only of late years that the results of the mal-utilisation of land have appeared to be a problem which must be approached from a wide angle and with a wide outlook. I do not mean that we were not conscious in the past of the mischief caused by what is comprehensively known as erosion; for erosion takes many forms and indeed we should perhaps be more correct if we stated the matter as the general problem of the conservation of the fertility of the soil. In many areas, the question had already begun to receive serious attention. But perhaps the fact which first gave it world-wide significance was the revelation of the great mischief caused in America by the misuse of land. It is now recognised everywhere as one of our major problems. In passing through Africa I have seen the active steps which are being taken to introduce measures by way of controlled methods of cultivation and the reservation of forest land to repair the mischief caused. Clearly it is difficult to say how much that mischief is due to nature and how much to man; but the mischief is there. We are also now taking more concerted measures in India.

The problem has to be approached scientifically, and I think we could have no better guide to the history of the question, or to the measures which have to be taken to repair the mischief, than Professor Stebbing. He has approached the subject partly in the light of his experience as Professor of Forestry, but he has also approached it from a wider outlook. He has taken particular interest in one question which has disturbed people's minds in Africa, and which may be shortly described as the "March downwards of the Sahara."

The following paper was then read :—

What is the connection between Erosion and Water Supplies ?

Probably the first recognition by man of the damage committed by erosion came from the method of farming by shifting cultivation practised for a very long period of time in the afforested parts of the globe, under which a very large area of forests either disappeared entirely or was destroyed so far as its commercial value was concerned; for the area formerly occupied by valuable timbers became overgrown when the shifting cultivator left it with weeds and worthless soft-wooded trees; the species depending upon the parts of the world concerned—Temperate or Tropical.

The shifting cultivator, as also the pastoral stock keeper, made use of fire to assist the forest clearance, and, unchecked, these annual fires spread across the countryside. Erosion began to play its part, at first most noticeable in hilly regions.

It is a mistaken idea that tropical forest will continue almost indefinitely to provide new land for colonisation.

This type of forest in fact requires careful treatment. It is a very delicate organisation and the action of man may now be opposed to that of Nature, who holds the scales. In the part in certain countries considerable areas

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* Paper read before the Royal Society of Arts on 28th February, 1945.

of this type of forest have been destroyed to grow plantations of coffee, rubber, and so forth; or opened for purely agricultural purposes, with an almost inevitable result that erosion has taken place, the surface soil has disappeared, and the waters have dried or sunk deep into the lower strata and beyond the economic reach of man. Without stable water supplies agriculture becomes impossible on any sustained basis. Therefore it is of equal interest to the agriculturist and the forester to know where his water supplies come from in the particular part of the world he is working in.

A glance round the world to-day will furnish evidence of how few inhabited countries are unaffected by this question of erosion. Britain has her problems, and in Europe, to mention a few cases, France in the Alps and Pyrenees had to undertake great protective works to stop erosion; or, in the case of the Landes, the planting up of the inward-moving sands; Spain, Italy, Greece and Cyprus all show striking illustrations. In the United States and Canada the gigantic so-called dust bowls furnish the most modern instances. In the British Empire, the Dominions of Australia, New Zealand, South Africa, the Rhodesias and the Sudan are facing problems, some of the first-mentioned of equally recent origin. In India and Ceylon, erosion and its results have been studied for a century or more past, especially in connection with the planting of coffee, tea, and so forth. Palestine with the neighbouring Trans-Jordan, considerable parts of the old Continent of Africa, irrespective of the nations ruling the various peoples—Britain, France, Belgium and Portugal; in the West Indies, Jamaica, Trinidad, Leeward and Windward Islands—all these countries present complex problems of which the basic cause has been so often man's improvident actions.

It will be of interest to consider for a moment what is meant by the term "Erosion." There are several distinguishable types—Sheet Erosion, Gully Erosion, Soil Erosion due to over-cultivation, Soil Erosion due to excessive pasturage, Soil Deterioration, *sur place*, due to the removal of heavy tropical forest with a closed canopy to grow arable crops or areas of coffee, cocoa, rubber, etc., Sand Invasion, and Desiccation. The main result in each is the disappearance of the top layers of valuable productive soil and the lowering of the water table in the soil, with the drying-up of springs and the lowering of the water in streams and rivers. Instances are not uncommon when one or more of the types may be operating together, or may succeed one another.

The Influence of Forests on Rainfall is a much debated question, and has been under discussion by foresters, agriculturists and others for well over a century and a half in Europe, over a century in India, and over half a century in the New World. Briefly the question is by no means settled for the temperate parts of the world; in the tropical and semi-tropical parts for practical purposes the question appears to be no longer open to doubt. The climatic conditions in these regions are (1) great heat in a dry season; (2) heavy rains following, with a high temperature; (3) a comparatively cool quiescent period for plant growth. Wind plays a part in (1) and (2). Under these conditions the forests should be regarded as Nature's large reservoirs from which the water of the heavy rains period dripping from the leaves (the canopy breaking the heavy fall) and running down the stems of the trees falls on the humus layer on the forest floor, and slowly percolates and reaches and fills the springs and streams, thus keeping the level of the rivers out in the plains at a fairly uniform annual amount. In other words, there are but rarely large rises in the levels of the rivers, which produce floods and destruction, counter-balanced by heavy drops in the water levels in the rivers and drying up the streams in the hot season. These remarks apply also to the level of the water in wells and the artificial reservoirs built by man unless artesian water has been tapped. Of course, this action of the forest is equally true in temperate regions.

If by inadvertence we leave our large pre-war sponge in the bath when, eventually, it sits on the bottom, the water in it only gradually percolates away down the drain-pipe. If after a few hours we return we shall find the sponge nearly dry, but the water it held has only slowly reached the drainpipe. This represents the action of the forest subject to heavy rainstorms whether prolonged or otherwise, and is, therefore, one of the functions of the forest *vis-a-vis* rainfall; the water reaches the streams and rivers slowly, and is conserved for a longer period and more evenly distributed throughout that period.

As to the direct influence of the forest on rainfall, whether the forest actually attracts rain clouds, research which has been carried out to some extent in tropical countries in the interest of agriculture would seem to show that under certain conditions the presence of forests has probably some influence and certainly so on climatic factors. As a result of researches carried out by Nicholson and Walter in Kenya and Uganda, they stated as one of their conclusions that, under favourable circumstances, mountain forests in East Africa can induce occult precipitation up to at least 25 per cent. of the total annual rainfall. It would appear to be beyond dispute that once Nature's balance has been severely upset by the clearance of an excessive amount of the forests on a countryside the water table begins to sink in the soil, the rainfall becomes inconsistent and unstable, periods of drought set in, at first followed by periods of normal rainfall. But as the soil conditions deteriorate, the climate in the absence of the former considerable forest areas becomes drier, rainfall becomes more intermittent and no man can foretell whether he will receive in any one year a sufficient amount to ensure successful crops.

It can be suggested that the chief causes of the troubles which have been experienced in this matter are due to man's often quite unmeaning interference with the equilibrium of Nature. In this small island of ours floods are not unknown. We need go no further than the Thames for an illustration. Did the Thames flood between Windsor and London in Roman times? I wonder! Banking up a river with embankments, wharves, and so forth naturally constricts its bed. But this is not, I believe, the whole answer. We have no reason to believe that the rainfall is heavier now-a-days than it was sixteen or seventeen centuries ago. But there was certainly more forest on the head waters and catchment areas of the river, and of other rivers throughout this island.

In the time of Charles the First, the Forest of Dean stretched down to the shores of the Severn River.

Before the end of the eighteenth century its boundaries nowhere reached the river. In the lower reaches below Gloucester the Severn, once a noble stream, now shows at low tide great stretches of mud banks. Moreover, records of the past century-and-a-half show strange changes in the current, both inward with the tide and outward, sweeping away areas of valuable agricultural land. How swiftly such a change may result in loss was seen only last year (1944). At a certain point the river runs past a piece of cliff about twenty feet high or so at a slight curve. A short branch line of the neighbouring railway runs close along the cliff edge and to safeguard this the railway authority had built three stone dykes and this had efficiently protected the cliff, generally of clay, from wash-outs. Early last year the river current changed its course and set dead against the cliff. The water quickly undermined the dykes, washing them away. Within three months, here in temperate England (it would have proved to surprise in a tropical country during the monsoon months), thirty-seven acres of valuable arable land had been washed into the river. Beyond the railway line a "hush-hush" war factory had been built and was in full operation; the manager, when the danger became obvious to both the railway and the factory buildings immediately behind it, made representations to London. Within a couple of days cranes and giant shovels, lorries filled with great stones arrived, and they started the work of refacing the rapidly-eroding cliff face. The measures taken were effective, even if only of a temporary nature. Heavy fellings had been made in the Dean Forest and elsewhere in the region for war purposes. Water supplies during last spring and summer were extraordinarily short on a countryside where one would never have suspected that such a state of affairs could have supervened. London, as we all know, has also had its troubles, not for the first time, in connection with its water supplies. Why should this be so in this moist island of ours? Should we not go to the catchment areas for the answer?

India furnishes some interesting illustrations. Attempts have been made, perhaps naturally, to classify soil conservation measures into agricultural, forestry and engineering. There are, unfortunately, many areas so destroyed by man's actions that probably only great expenditure will bring about partial restoration. It appears, however, to be often accepted that, in any event, no conservation efforts can be commenced until a considerable programme has been drawn up and the estimated expenditure involved sanctioned. This is, however, by no means always necessary. In the past it

has been often the failure to consult and accept the suggestions of the experienced forest official, or the failure of that officer to recognise the portents, which has so often precluded or retarded the beginning of reclamation attempts. It is often held that the country in which to study soil conservation and reclamation work is the United States. Certainly much research and fine work has been undertaken in this connection and on a grand scale. I am not sure, however, whether for the purpose of parts of the British Empire, *e.g.*, the Colonial parts, India cannot offer some better illustrations; in the Punjab, to give one example.

From a note of the Inspector-General of forests in India on a visit paid in 1943, it becomes obvious that the general impression that the counter-erosion work in the Punjab, with its relatively small rainfall, but heavy storms, depends upon contour trenching, gully plugging, check damming, and so forth, is incorrect. In other words, that the cheaper and more ordinary methods of closing the area to grazing and firing and, if necessary, assisting by afforestation are often sufficient. In some parts of one area which have been closed to grazing for forty years, and effectively so for the past eight years, only grass-cutting being permitted, the improvement compared with unenclosed areas is obvious and remarkable and vegetation is far denser than in the unenclosed areas. Again, the catchment area of Dholbaha, 20,000 acres, discharges through a narrow *cho* (stream bed) which fans out as it leaves the hills into a wide area of sand. In this 20,000 acres one-third has been closed to grazing for forty years; the rest closed to goats and cattle on a two-year rotation. Both areas are open to grass-cutting. The rotational closure has less effect, though the closure to goats has increased bush growth. The area which has been closed for forty years is improved out of all recognition. It is hardly possible to believe that this now moderately well wooded area with a large percentage of Chir Pine (*Pinus longifolia*) had ever been so barren on eroded as the unclosed areas. The run-off must have been largely reduced.

Going from south to north through the Siwaliks into the Jaswan Dun you see the bare Siwaliks again beyond that, separated by the valley of the Beas from the main Himalayas further north. This country is very like the southern part of the Hailey Park in the United Provinces except that there is far more middle Siwalik conglomerate in the northern portion of the Hailey Park and a much heavier rainfall. But while in the Hailey Park there is no serious erosion problem and the whole is coverted with moderately dense forest or grass, these Siwaliks south of the Jaswan Dun are a picture of devastation and erosion. Here again, however, areas are being closed to grazing or at any rate it is being regulated, and whenever an area is closed vegetation very definitely improves. Jaswan Dun itself contains cultivation but is very largely sandy or swampy land by the excessive run-off from the bare Siwaliks to its south and north. Yet there is no reason whatever why, if these Siwaliks were covered with vegetation, this Dun should not compare with Dehra Dun in fertility and productiveness. On the subject of the work done in the Pabbi Hills, the Inspector General of Forests says:—"This country is very like the ravines of the Jumna and Chambal. A great deal of gully plugging, contour trenching and artificial regeneration has been done at great cost, but, excellent though it is, it is the vegetation, whether as a result of closure or artificial regneration and not the engineering, which fairly obviously now has had the greatest effect. This would not be so apparent in the first year or two of closure.

"Compared with the total area of closure of one sort or another there is little gully plugging, contour trenching, check damming and the like. The forest department here rightly look upon the natural process of encouraging the spread of vegetation, principally naturally and supplemented artificially as the basis of their work. They use all these minor engineering works of gully plugging, check damming, contour trenching, etc., to aid them for certain special reasons in certain special places, but they are all used for some special purpose in a special place and are not either the principal or the general method of tackling the problem. The Chief Conservator in a tour note has written:—

"Trenching is far too expensive to be done on a large scale and dams, though certainly useful, are hardly required at this stage, as the greatest success is being attained by simple closure. Even this very broken ground is producing a crop of grass and bushes which will be of local value in addition to serving as a check to erosion. I do not want to say that trenching and gully plugging are useless but

their effect is entirely subordinate to that produced by nature in re-clothing with grass and vegetation barren hill sides. Closure is essential, and engineering works cannot succeed without it or ever have comparable effect. This agrees entirely with the experience gained in the United Provinces on counter erosion works in the ravines of Etawah (on the Jumna between Cawnpore and Agra) begun some thirty years ago. Contour trenching and the like is an excellent way of dry farming to get regeneration, if it is necessary and if it is worth the cost, but as a method of erosion and flood control in these areas is of itself both expensive and ineffective. Moreover the making of contour trenches on a grassy slope may break the stability of that slope and actually start erosion."

These are some of the latest opinions from Indian experience in these matters.

It is not proposed to deal here with the crop cultivation methods which have resulted in the formation of the disastrous dust bowls in the United States and Canada. Suffice it to say that the over utilisation of the soil in the production of wheat and cotton has resulted in some 900 million acres of land in the north, central and north western states being ruined and threatens even larger areas on their outer perimeter, the same applying to the prairie farms of Saskatchewan and Alberts in Canada. The other example of the results of disafforestation of catchment areas on the grand scale is exemplified by the gigantic floods on the Mississippi and Ohio rivers in 1937.

In 1943, C. A. Connaughton, Director, Rocky Mountain Forest and Range Experimental Station, wrote:—"Service of water-sheds is one of the most important contributions that wild mountain lands make to the semi-arid West. Their utility for water-shed purposes is influenced by a number of factors, of which those associated with the kind and density of vegetation may be manipulated in co-ordination with other uses to obtain optimum fields of usable water. Since the benefits of land for water yield may often be less direct than the returns from other resources, land managers are cautioned to guard against subordinating water-shed services to other usesat the expense of the public welfare."

In Australia it is admitted that a century-and-a-half ago the first settlers found a land which appeared to be one vast forest in which the nomadic aboriginal was so primitive that he had not acquired the art of tilling the soil. By the end of the century-and-a-half the development had been so rapid that nearly all land capable of growing crops or of raising flocks and herds had been wholly or partially worked. Fortunes were made, but the misuse or over-use of the land upset the balance of Nature, and their greatest national resources, soil and water, have been impaired; and owing to all failure to plan the formerly fruitful soil, has in many cases, ceased to yield a return. Erosion by wind and water, the well-known "soil drift," has taken a great hold over considerable areas which have been turned into deserts. In the mountains overgrazing and fires have attained dimensions which endanger the catchment areas of the waterways—rivers like the Murray which are not confined to one State, but on which two or three are dependant for water for irrigation. Floods are becoming more serious, and rivers, once secure between their forested banks, are tearing away alluvial soil and bearing it down to the sea. This is a quotation by an Australian. Soil drift in the arid pastoral areas of South Australia is well-known as also the constant "Droughts." Few years pass in which the press has not some serious reference, such as the report from Canberra of 27th September, 1944, on one of the worst droughts in history had befallen Southern and South Western New South Wales. The wheat harvest would be only 50 per cent. and thousands of stock were in peril unless rain fell soon. Horses were selling at 2*s.* 6*d.* or being shot, and ewes at 4*d.* Victoria also needed rain and there was a sudden famine in Melbourne. It is pertinent to our subject to ask, were there any droughts of this type in Australia a century ago?

In New Zealand in a recent Forestry Department Report, on the subject of "soil Erosion," it was stated: "The Forest Service continues to advocate a realistic approach to the problem of soil erosion through dominion wide control of land-burning operations. No other measure can give such effective results either as quickly or as economically. So aggressive is the New Zealand vegetation that no ground is too barren to resist its invasion—that is, if burning is controlled instead of repeated and uncontrolled. Even much of the harmful effect attributable to over-grazing is a direct result of indiscriminate burning, and would, therefore, be corrected by control of firing operations.

Simple as the premise is it provides the most practicable and economic method of preventing accelerated erosion." This considered expression of opinion could, I think, be usefully studied elsewhere in the Empire.

Space will preclude consideration of the European countries bordering the Mediterranean or the islands, such as Cyprus, where the goat has been one of the chief causes of erosion.

Palestine displays one type of the Middle East—covering some 10,000 square miles, approximately half plains, half hills. The hills, once undoubtedly covered with good soil and forests, are now eroded with probably less than one per cent. of agricultural land in good condition. The river valleys are desolated by floods and the deposition of infertile detritus; river beds are choked and railway embankments and bridges frequently damaged. Excessive grazing and uncontrolled cutting are responsible for these conditions of what has been termed artificial desert in Palestine. Perhaps most significant is the fact that there is no fire danger because there is not enough even scrub forest on the countryside to enable fires to spread.

The general management of the West Indian Colonies in the past is an example of concentrating on the production of paying crops which quickly raised the status and wealth of the colony and its inhabitants while ignoring the inevitable results of upsetting Nature's balance.

The problem, as a result of the great work of Sir Frank Stockdale, is now being handled in a masterly fashion and needs no further comment here; with the one suggestion of the vital necessity of restoring or rehabilitating the dilapidated forests on the important catchment areas in the interests of an improvement in the water supplies, and to arrest further erosion.

In one way and another Africa presents one or more of these erosion problems, and at times two or more acting in conjunction in a variety of aspects.

In the Dominion of South Africa the main pre-occupations appear to be wood and water. The present war has brought up very prominently the known deficiencies in the former. In a country where large arid and semi-arid soils exist and little indigenous forest, a deficiency of wood would be a natural pre occupation. The Dominion in this respect is in the same position as Great Britain importing when possible, large amounts of soft woods; and also envisages an increased afforestation campaign after the war. In the case of water supplies irrigation and large storage tanks have been the chief methods of assisting agriculture. In the extensive wild grazing areas of the veldt, where state funds are to be spent, modern opinion appears to favour assisting the stock farmer by the provision of drinking water and irrigation for the growth of fodder reserves in order to stabilise the animal industry. Irregularity in the rainfall occurs, and this intermittency appears to require further study; since, although underground water has been used through borings by the State, in some parts it is said there is no actual water table, the supplies being maintained by infiltration through previous strata from annual rainfall.

In Bechuanaland, Swaziland and Basutoland water and erosion are serious problems. In Bechuanaland boreholes have, in some parts, proved failures owing to brackish water. Apart from erosion, the chief problem appears to be drinking water for the people and their cattle. Improvement of the river beds by the removal of silt, which would necessitate the maintenance under forest of their catchment areas, thereby stopping erosion, the construction of storage dams and the development of underground sources have been suggested. Swaziland is blessed with numerous streams and rivers; the question of irrigation on the large scale and the objectives to be aimed at is under consideration. In Basutoland a loan from the Development Fund is, it is believed, to be spent in the construction of small works partly for crop raising but chiefly in anti-erosion measures. A former District Commissioner in this region gives the following eye-picture. In the early days there was land and to spare for the small population and for their cattle and sheep. Internecine warfare ceased, more and more land was opened up, population and stock increased rapidly until all available land had been occupied; as a result of over-utilisation erosion commenced. Rainfall diminished in the Spring. Round about 1900 thunderstorms occurred in August and onwards. Now it is more usual for little rain to fall before Christmas. Contour furrowing and reservation of water in dams were introduced. The district officer

anticipated the Inspector-General of Forest in India by remarking that, unless contour furrowing was done carefully, erosion might be started, especially on grassy slopes, while the breaking of the veldt in Africa often gave rise to a dense weed growth which led to waterlogging.

The Rhodesias—southern and northern, are in rather a different position. No irrigation works of any size have been undertaken. It is too big a subject to deal with here. It may be suggested that, in the interests of the mines and the labour forces employed by them and their requirements in firewood and so forth; in the interests of the farming and its dependence on the bush; in the interests of erosion and water supplies in some parts of these countries; in all these interests reservation of forests is a matter of some importance, if mainly for protective reasons, apart from their capabilities of supplying and maintaining supplies of timber and other products. In Southern Rhodesia the State maintains an engineering and well-boring establishment which carries out drilling for farmers. The following, written to me in 1938, gives a picture of Southern Rhodesia:

"Last year on this farm I had about 21″ of rain, which practically all fell in six weeks, from the middle of December, 1937, to end of January, 1938, the worst season for ten years, and all my streams are consequently lower than I have ever seen them.

"Although the natives here have 30 million acres set aside for them as reserves, some 130,000 live in the White Area on Crown land, which, I have no doubt, they are destroying, as rapidly as possible. Ten families destroyed on this farm at least 300 cords of wood in a short time, and there are no adequate penalties at law to stop similar destruction in reserves, etc. The increase in the native population in twenty-five years is amazing, as also the increase in their cattle. The destruction of wood by natives and by tobacco growers is enormous and there is no compulsion on anyone to replant.

"On the Vumba mountains on which is the boundary between Portuguese East Africa and ourselves, we have a 60″ rainfall as a rule, but erosion occurs there due to cattle going to water, roads undrained, and natives making gardens (farms) on the hillside. Few people plant forest trees."

The rest of Africa, south of the Sahara from Senegal to the Sudan has many characteristics in common, the regions perhaps of chief importance and most discussed lying from Sierra Leone to the Sudan. Between are situated the Liberian State, the Ivory Coast, Haute Volta, Gold Coast, French Soudan, Togoland, Dahomey, Nigeria, French Niger, the Cameroons, French Equatorial Africa, Belgian Congo, the East African Colonies of Nyassaland, Tanganyika, Uganda, Kenya and the Sudan to north. From half to two-thirds of this great area of Africa is covered by the so-called bush or Savannah, variously degraded from a former high forest, becoming more open and of thorn-like character as it goes north on the confines of the Sahara. The method of farming depending upon the bush is the method known as shifting cultivation—but the villages are fixed and the Chief and his people practise this method on a definite area of country in their proprietorship. Population and stock may increase in numbers, but the area of land remains constant. The result is that the fallow period or number of years intervening between cultivating and re-cultivating the same site becomes shorter and the return of crops poorer in amount and value. Added to this the climate becomes drier and the rainfall shows on intermittency. This is no new thing. It has certainly happened in the past centuries and we are only witnessing an often-repeated story in the world's history; but owing to a settled government the rate of the dessication and interference with man's pursuits is becoming more rapid.

The tsetse fly also adds to the difficulties of the land problem in some parts.

It was from the French and from the North Sahara that the first reports came in connection with the Sahara. Duveyrier (*Les Touareg du Nord*, 1864), gives reords of the existing vegetation and forests, some of which have since entirely disappeared. Between 1898 and 1906 several expeditions were made southwards into the Sahara, with the progressive occupation by the French, and the question of dessication commenced to be discussed in French circles. Later reports and papers are connected with the Colonies in the south, on the fringe of the South Sahara boundary. Henry Hubert, a chief political officer of long service, and another high political officer in the Haut-Senegal-Niger region both voiced the opinion that dessication was increasing and that wells in their regions had dried up in their own time whilst the rainfal

had become very unreliable. Hubert cites Mauretania where there was once a dense population but is now only a great desert. The results of his study of the position were published in 1920. In the following decades several senior French political officers who had passed most of their service in the arid regions situated within the boundaries of the southern Sahara and immediately to the south, expressed similar opinions on the increasing dessication. This strip of country eastwards to Lake Chad lies immediately to the north of the British Colonies.

Quite apart from any investigations made by myself the statement that the Sahara is advancing southwards was recorded by two senior French officers during the last ten years, each having passed thirty-five years of his service in these French colonies. Put in a few words the dessication is attributed to over-cultivation by an increased population restricted to their own lands, over-grazing when the latter replaces cultivation, to the custom of annually firing the bush and to unchecked cutting in the bush. One of the outcomes of these operations is a reaction in the annual rainfall supplies previously received. The first reaction appears to be not so much in a decrease in amounts received as in the failure to receive it at the appropriate time. The fall may be delayed at the sowing season necessitating the re-sowing of the seed. The process of dessication is slow and man is slow to recognise that anything is wrong. But the rainfall gradually shows a greater intermittency, sowing becomes more of a lottery and, with the decrease in density of the bush, blown sand increases in thickness over the soil layers.

Several influences are at work—erosion due to drying of the exposed surface of the farms and the blowing away of the upper rich particles of the soil combined with sand penetration coming from the nearby desert, and the failure of the rainfall at the required time, together with the smaller amounts of the fall; it is the combined results of these influences which are gradually causing the population to move further south. One heard on more than one occasion from the French in the Ivory Coast and Haute Volta that their people (in the colonies bordering on the South Sahara) were moving south into the British colonies. This was not primarily due to the French conscription, but I think, from observations I was able to make, due to the increasing dessication in that strip of French colonies immediately to the south of the Sahara proper.

In their Report a West African Commission appointed by the Leverhulme Trust under the heading "The Advance of the Sahara" wrote: "The dramatic onset of wind erosion in the 'Dust Bowls' of the United States in the early nineteen-thirties created uneasiness in many other countries. There was something approachingalarm in certain quarters when after a recent visit to West Africa and a journey across the Sahara Professor Stebbing of Edinburgh suggested that there was more than a possibility within the next fifty years or less that Kano itself might be overwhelmed by the Sahara, should the present methods of agriculture, grazing and firing of the bush to the north continue on an increasing scale. Fortunately, one part of the problem has recently been examined by a competent Anglo-French Forestry Commission which failed to find any definite evidence of increasing aridity or any general danger of desiccation."

Owing to a misunderstanding or misreading of the remark made in a paper on the subject I read before the Royal Geographical Society it was implied that I envisaged the Sahara as advancing in rolling waves like the sea breaking on the shore under a rising tide. Consequently, as was explained to me afterwards, the Commission spent a proportion of its time in searching for moving sand dunes from which Professor Stebbing's "*vagues*" could emanate! I remain of the same opinion about Kano and I believe an International Commission of countries having jurisdiction in Africa with carefully drawn up Terms of Reference would possibly be the only way to settle upon agreed steps to be taken—soil conservation to use the modern term—if the threat, a very long standing one, is to be laid so far as this may prove possible.

In connection with such a study I would suggest that the determining factor as to how far dessication, to use the word in its widest sense, has gone, depends upon what I call the intermittent rainfall. Lavauden, in his "*Les Forets du Sahara*" wrote:—"In the middle of the Quaternary period, an epoch which it is impossible to date precisely, the Sahara was a very humid region, the fluvial system was of a particularly powerful type, allied without doubt to very abundant precipitations. To-day

all these river beds are dry, and only the largest retain underground water of which the amounts constantly diminish—slowly perhaps but inevitably—owing to *the equilibrium existing between precipitation and evaporation*. An important question is to determine at what epoch the disequilibrium between the two commenced to make itself felt; in other words at what period dessication commenced to become seriously apparent."

This represents exactly what I term intermittent rainfall. If in each case we can determine the exact stage at which this disequilibrium between precipitations and evaporation has reached, based on the now intermittent character of the rainfall, we shall be in a position to settle upon the measures to take to restore where possible the necessary equilibrium.

During the last decade a very considerable amount of investigation work has been undertaken by officers of the Colonial Services, and this combined with his own investigation has been epitomised in a masterly fashion by Lord Hailey in his work *An African Survey.*

In defining the functions of forestry in Africa, Lord Hailey said that the importance which frequently attaches to a forestry regime lies not only in the extent to which timber can be exploited, but also in the direct protection which forests afford to the water supply, or their influence on climatic conditions, both being of vital importance to the methods of livelihood of the African communities. Read the history of the past eighty years in India the less on, with backslidings it is true, has been learned there. Read the history of the past forty years in Africa. Forestry was largely governed by the annual revenue obtained from the forests. This may now be regarded as the history of the past.

A new orientation of the point of view has latterly come upon the scene, started to some extent from the inception of the Colonial Development Fund, which, small beginning as it was, led to such quick results in some colonies under the able guidance of Sir Frank Stockdale.

The new conception of the problem to be faced is being drafted as a result of soil conservation committees consisting of carefully chosen officers from the administrative, agricultural, forest, veterinary and engineering departments, with the assistance, when required, of the geological, meteorological and medical departments. Some draft reports have been published, and work has been commenced in some colonies. It is evidently of a type which requires careful collaboration before large sums are expended, such sums as will now be available from the far-sighted statesmenship of the Secretary of State for the Colonies. His recent epoch-making bill, the Colonial Development and Welfare Bill, which has been accepted by the House of Common's sanctions the expenditure over a period of ten years, of a sum of £120,000,000 on colonial development.

As an example of this new attitude the Sudan has published a Report of their Soil Conservation Committee which gives a very complete exposition of the case. The greater part of the Sudan comes under a zone of instability where natural conditions allow vegetation of a certain type to flourish, but in which zone a slight disturbance of conditions (natural or human) may tip the balance in favour of destruction of vegetation and allow the recession of the zone and the enlargement of the arid or desert zone, where, says the Report, "nothing can be done by man to ameliorate the conditions." Amongst the recommendations for Kardajan are:—"The existing system of attempted fire protection to continue, in view of the nature of the grass vegetation, the grazing situation, and the comparatively advanced state of the public conscience in the matter, fostered as it is by the money value of the gum stocks. The early adoption of 'national' fire lines either from Duein westwards or through the latitude of Um Dam." In discussing the Equatoria Province the Report says "the immediate effects of fire are: (1) to kill tree seedlings; (2) to kill some perennial plants and permanently damage others; (3) to burn up vegetation debris; (4) to destroy humus; (5) to expose and dry the surface of the soil. Others secondary effects are discussed and the causes for the prevalent habits of firing the countryside in Africa"; and ends up with "it is obvious that the bad effects of fires far outweigh any good effects that they may have."

It may be suggested that the work of these Soil Conservation Committees would be greatly simplified at the outset if some attempt was made to decide upon the rough boundaries or types of areas which fall to (1) agricultural investigation; (2) forestry investigation: this might save duplication of work at its initiation;

and (3) a third group occupied with investigations into the intermittency of the rainfall, undertaken district by district; for this undoubtedly will underlie and form the basis of the whole of the enquiries and investigations.

The objectives of each should not be difficult to prescribe or assimilate; for instance, perhaps the first objective of the forestry department would be to select within its own area blocks of bush or forests which would be recommended for strict closure to cultivation, grazing, firing and cutting—apart from a careful assessment of catchment areas, in connection with the amount of rainfall being received in the region, and the available supplies in the arable land below the catchment area.

There can be little doubt, as has been proved in India, and in a few cases in Africa, that such closure, assisted where necessary on the lines carried out in India with the same object in view, will produce within a comparatively short period of years remarkable results; and this action has the merit of being cheap whilst ensuring in the future an adequate supply of small timber and other products which will be in demand by an agricultural population, by then settled on a more permanent form of arable production. The grazing areas will have been improved by a rotational cropping. One function of these great forest blocks will be the protection to the countryside they will afford, while assisting to stabilise the water supplies of the region. In the future they will afford further areas of a greatly improved soil for cultivation, required by an increased population. The large closures made in the first instance therefore by no means indicate that the whole of the area will remain permanent forests; as in effect, has often been witnessed in India where the Civil Department has taken over blocks of Government Forest, later required for agricultural purposes. In Africa, however, in general, many of these great closed blocks of Savannah will have as their chief function for years to come a protective character, while at the same time helping to rebuild the water supplies and bring back a more stable equilibrium in these matters than exists at the present time.

Finally, it may be suggested that this is by no means a matter for individual districts, each working in parochial fashion. As is well known a river in one district, and its catchment area, may be depended upon to furnish a large part of the water supplies for districts situated at a considerable distance. Collaboration on the broadest lines over a whole region having more or less the same characteristics will be required.

It will be inevitable that the problems in some districts will extend outside the British frontier and that districts may be adversely effected by what is taking place on the other side of the frontier. A strong case would appear to exist in Africa that the powers who are chiefly responsible for the improvement of the conditions of life of the people should come to some common agreement upon the general steps to be taken in this grave matter.

In a paper published by the Royal African Society in January, 1941, the suggestion was made that the ideas on the subject of dessication and erosion in Africa of the Governments concerned might be pooled, since the Administrations of several of these Governments were in London. Under the auspices of the Society a small Commission on Research for Africa was set up and representatives from Free France, Belgium and the Netherlands Governments in London were invited to serve, with two British representatives. The bulk of the members were administrative (political) officers. The Commission came to unanimous conclusions on the subject of shifting cultivation, bush fires, grazing; reservation of forests, and erosion; and made practical proposals for dealing with these evils, evils which, it was freely admitted, the various administrations had refrained from touching for so long, being unwilling to interfere with the habits and customs of the people.

My own personal reaction to the work of the Commission came in its early stages, when hearing voiced by the foreign officials, each for the regions in which he had served, problems of erosion and water supplies, grazing, firing of the countryside and unchecked hacking and cutting of the forest areas, problems which I had first commenced to study well over thirty years earlier in India. I do not know why I should have felt this surprise—but listening to problems of the Belgian Congo, French Equatorial Africa, and the Dutch East Indies in these respects, brought the fullest realisation that the problem was, in its main issues, a common one in many parts of the world, with variations for different conditions and peoples; and that probably the Continent of Africa possesses a greater similarity in conditions, and smaller differences in the main aspects

of the causes for erosion and dessication taking place than is the case with other affected parts of the world.

I would make the suggestion that an African International Commission of the four countries chiefly concerned, Britain, France, Belgium and Portugal should be got together—no one better qualified to fill the post of Chairman could be found than Lord Hailey—to co-ordinate the lines of soil conservation work to be taken. The more one studies the map the more interlocked the zones of influence of the four Powers appear to be in this matter.

There are actions of the people still practised unchecked which, in the opinion of some, spell eventual ruin to the descendants of those still carrying them out. The representatives of the four governments represented on the Royal African Society's Commission all admitted the difficulties in giving effect to their recommendations. That position still remains. It would appear that to tackle it in the only practical fashion to produce results will be for the governments concerned to come to an unanimous agreement as to the action to be taken through the pronouncements of an authoritative commission whose findings would be accepted outside the confines of Africa or the governments concerned.

DISCUSSION

THE CHAIRMAN:

I draw consolation from one of Professor Stebbing's conclusions, namely, that the measures needed for repairing the mischief done are not necessarily very expensive. Indeed, the most efficacious measure is the closure of pasturage. Engineering work is no doubt required on the upper reaches of streams, but lower down, where sheet erosion is the main danger, closure of pasturage is one of the most effective measures which can be taken. May I add to the facts already given one which I recently learnt about Basutoland? Some years ago we decided to take active action there and we provided a considerable sum of money for engineering work; but we went further and succeeded in eliciting the support of the native authorities in a programme of closure of pasturage. They were able to do what we were not able to do ourselves in some of the British Colonies: they put a taboo on the use of land for pasturage for certain periods of the year. A short time ago we asked an American expert in erosion matters to visit Basutoland. He told us: "You need hardly have asked for me; you have done all I could have advised you to do and with marked success."

Another conclusion which is obvious is that work of this kind involves co-operative teamwork of a comprehensive character. There is the forester; the botanist (with all that he can tell us of new methods of introducing drought-resisting grasses); the meteorologist; the scientist who can tell us about the difficult problem of evaporation from certain trees; the agriculturist, who is concerned with contour trenching and the extension of methods of mixed farming to take the place of shifting cultivation; the veterinarian, who, on the one hand, is interested in the preservation of cattle by controlling epidemics and, on the other, is interested in elimination of useless stock by cutting or by upgrading. And there is, of course, the administrator who must come in to co-ordinate their work and use his own influence to see that the right measures are introduced and observed.

Professor Stebbing suggests that in Africa we need some co-ordinating committee of the four Colonial Powers chiefly concerned. It is not difficult to get together agencies for joint consultation where research is concerned; scientific men recognise no nationalisms. But where joint action is required it is more difficult. I hope, however, that some useful results may follow in this field if practical effect is given to the proposal for creating Regional Councils or Commissions in various parts of the world to deal with colonial problems. If there were a commission of that nature in Africa it might be effective in concerning measures which would go far to meet the mischief caused by erosion in its various forms.

Sir THOMAS DUNLOP: May I offer our grateful thanks to Lord Hailey for taking the chair this afternoon and for conducting our meeting so ably?

The vote of thanks was accorded by acclamation and Lord Hailey then left the meeting.

Dr. H. INGLESON: I should like to know whether the lecturer has any idea of the reason why the presence of trees affects the time and the quantity of rain falling on a particular area and why the removal of those trees gradually affects the time of year at which rain falls and the quantity of the rainfall. Is there any explanation of that?

Mr. J. MOREWOOD DOWSETT: Lord Hailey has said that soil erosion is a major problem. It is certainly the most serious problem in the world to-day. I think that all who have had the privilege of hearing about it should make it their duty to spread the news of soil erosion far and wide. The more it is talked about the better.

Dr. W. N. TAYLOR: I should like to ask the lecturer his opinion on the relative merits, in re-afforestation, of planting soft woods, particularly conifers, and hard woods, particularly Australian gums. In South Africa gums are generally used for this purpose and some people think that gums have had a dehydrating effect on the country rather than the reverse.

Mr. W. F. PERREE: May I ask whether so far, there has been anything done, other than the expression of a pious hope that something is going to be done, to arrest soil erosion? In these various areas in Africa what agencies can be made responsible for arresting erosion? Should not the district officer be made responsible? After all, he has to deal with the population and he has got to see that the population is provided with sufficient a soil and it is not enough just to say that such-and-such an area ought to be protected. There should be somebody to see that it is protected. The administrator is the real person whose business it is to set aside definite areas and who should say which areas are still capable of being comparatively cheaply treated by closure before the more expensive work of re-afforestation is taken in hand.

Professor STEBBING: The first question was what effect the presence of trees had on the quantity of water falling on a particular area. That really is answered by some of the first remarks I made, namely, that whether tropical forests have any effect is still in dispute and as far as temperate climates are con-concerned is still a matter subject to a considerable diversity of opinion. So far as conserving rainfall is concerned, however, there is no question but that forests do conserve it as the water runs only gradually into the streams and springs and only gradually gets into the larger rivers. It is known that during past centuries great tracts of land where the population was small did not get the considerable rise and fall which is experienced now in many rivers. My advice is: study the catchment area. If we did that I think we should find the answer to what I understand is the problem to be faced in temperate climates.

One speaker asked about the relative merits of soft woods and blue gums. That is not an easy question to answer because my own view is that in the case of any country which has indigenous species the first duty of the forestry officer is to use them so far as possible before bringing in exotics. There are no large areas of indigenous forests in the Dominion of South Africa, and they do require many soft woods which they have to import and therefore they are planting and growing conifers. One point which came out during the conference of the British Forestry Association in Africa before the war was that some farmers were planting areas of conifers in the vicinity of their farms in order to improve the water supply; but the reverse was found to be the case, and as the trees grew they took the water away. I do not think any definite opinion about this was expressed at that conference but it is not really a difficult problem. When closure was first started in India during the last century steps were taken to close some bare hill areas and as a result of closure this is what was found twenty years later. At first the closure resulted in a sinking of the water table in the tank (reservoir), but gradually, as the trees began to have an effect and humus was built up, the result was a raising again of the water table in the soil and consequently in the tank. That is quite what one would expect to happen. The result was more water and better conditions with increased growth in these enclosed area. The interesting point, however, is this. When the closure is first started the water may sink, or rather there is less water available, but with the progress in density of the vegetation, *i.e.*, the first crop within the closed area, the water table rises in the soil. Therefore it is probable that you will find that the planting of conifers or Australian gums will be equally efficient. More than that I am not prepared to say.

Then there is the last question. I think the general question was who, in Africa, is the officer responsible for advising on the reservation of forest areas. That is the whole point. In India when this question of reservation was first taken up and the department was small it was not the forestry officer who had to make the decisions; that was the civil officer's job. The forestry officer was the

man who took orders when the decision was made. In Africa the reverse is the case. The Government does not own the land because ownership of the land by the chiefs is recognised. Therefore it is left to the forestry officer to try to persuade the chief concerned to reserve his forests. The forestry officer has no administrative jurisdiction in the district. If a particular chief happens to like the forestry officer it is all right, and the matter may result in a forest reserve being established in the chief's area. That is, I think, the answer, and a sufficient answer, to the fact that by the end of the last century, thirty years from the time of the formation of the Forestry Department, all the major reserves of forest had been made in India; while at the present moment or when the war broke out, only a fraction of the reserves required in West and East Africa had been reserved. There is a different point of view between Africa and India. The matter is left to the forestry officer in Africa and he cannot do anything unless the chief to whom the land belongs agrees.

In his opening remarks the Chairman, Lord Hailey, said he hoped that I should say something about the Hoshiarpur Chose. In my original draft of this lecture (which had to be abbreviated) on this subject I wrote: Perhaps the most notorious example of erosion in the British Empire, because one of the most quoted, is the case of the Hoshiarpur Chos. Punjab district reports of the 'eighties of last century were already dealing with this example of gully erosion on the grand scale, and much has been written about reclamation attempts in the years which have passed. In 1936 the Chos Act was to be amended to allow closure when two-thirds majority of the owners of the area demanded it. The Forestry Department was preparing a scheme for establishing a demonstration area in which all phases of reclamation and counter-erosion work were to be tried; Officials of the Co-operative Department to be appointed to encourage control of grazing and reclamation of Chos by planting. So monumental is this example of erosion that the Punjab Government are producing a general manual on counter-erosion work; and a text book on more popular lines is also to ye written.

POST-WAR FOREST POLICY FOR INDIA

(*Editor's Note.*—In continuation of the leading article under the above titlte in our last number, we have now received a copy of the Second Report on Reconstruction Planning drawn up by the Reconstruction Committee of Council. Forests are dealt with under Section 18 of Part II, which is reproduced below. It would appear that the Committee have accepted Sir Herbert Howard's recommendation to agreat extent.)

18. Forests

Figures published by the Economic Committee of the League of Nations in 1932 show that at that time the percentage of the total land area of the Great Powers of the Continent of Europe, maintained under forest, either Government, corporation or privately owned, was 44 per cent. in the case of Russia in Europe, 24 per cent. in Germany, 20 per cent. in Italy and 19 per cent. in France. Among the lesser Powers the percentage of forest rose to 74 per cent. in Finland, 55 per cent. in Sweden, 38 per cent. in Austria and 34 per cent. in Czechoslovakia. The average of all the European powers including flat countries like the Netherlands (8 per cent.), Denmark (9 per cent.) and including also Great Britain (6 per cent.), was 26 per cent., with very varying distribution as between Government corporation and private ownership. Though British India is shown as having 175,000 square miles (20 per cent. of her total area) under forests, Government or private, out of this area only 122,000 square miles (14 per cent. of the whole of British India) is Government forest and less than 100,000 square miles is under regular Forest Department management. Hardly less important, the distribution of forests in British India is far from ideal. Except for the Central Provinces, Bombay and Madras—that is to say, roughly speaking north of a line from the Gulf of Cambay to Calcutta—the forests under the Forest Department consist of a narrow strip in the north, in and along the foot of the Himalayas, the forest of Eastern Assam, the Sunderbans and some detached blocks down the Indus, in the south of the U.P. and in Orissa and Bihar.

2. The forests along the Himalayas are vital to India for many reasons, especially for the protection of the Ganges valley against the related dangers of erosion and flood: but the Ganges valley itself and indeed much of northern India plains are almost destitute of

forests from which the villagers can draw fuel and small timber, while over much of Rajputana and Sind and part of the Punjab the absence of forests is leading to a gradual desiccation of the country.

3. Considering the Indian climate and the general demands of the agricultural villagers, the minimum area of properly managed forests in India, properly distributed for protective purposes and to supply the general consumer and the village consumer, should be between 20 and 25 per cent. of the total area of the country, as against a nominal 20 per cent. under forests of all kinds at present and 14 per cent. for forests under Government control.

4. In the interest of the greatest good of the greatest number—a principle enshrined in the existing forest policy—Governments, Central and Provincial, will in future have to take a greater share in regulating the distribution, the management and the exploitation of India's forest wealth. A forest is a slowly maturing asset: there is little early return on the investment and the extension of the area under forest cannot with any confidence be left to private enterprise. Similarly as regards exploitation: not every owner, incorporated or individual, can resist the temptation to exploit the asset for a temporary gain at the risk of its early extinction, a result from which not only the owner but the countryside is the poorer in many ways. Private forests were steadily disappearing in India even before the war. Under the pressure of war needs and high prices private forests have in some instances been so over-felled as virtually to have disappeared. It will not be possible for Government to take up as forest all the land that is ideally necessary, in quantity and in distribution, to give India an adequate and properly distributed system of forests: nor will it be possible to interfere to the extent which a purely forest point of view would render desirable in the management of private forests; but to the extent that the general well-being of the country is involved, the time has come for an extension of the land under forests of one kind or another and for an extension of Government control over private forest management and exploitation.

5. With this background, the general correctness of which will probably not be disputed, the Government of India are examining a post-war Forest Policy based on the following salient points: the rehabilitation of Government-managed forests to compensate for advance fellings during the war: the campaign against erosion; and the extension of afforestation, for its own sake and to make available fuel and small timber to the ordinary village agriculturist. The first of these is largely a technical matter and will presumably be taken up by Provinces and States as a matter of course. Of the matters calling for policy decisions, the most important aspect of post-war forest policy is correct land management to minimize run off, floods and erosion both inside and outside forest land and the afforestation, naturally or artificially, of the dry belt below the 30-inch rainfall line. The second, but almost equally important, problem is the provision of small timber and fuel for the "ordinary village agriculturist," free or at low rates, both to provide for the direct wants and to release cowdung for manure. These problems are largely inter-dependent; to a large extent what solves the first helps to solve the second; to an even larger extent the solution of the second will help to solve the first. To these general ends a policy on the following lines is recommended:

(*a*) Provinces should endorse and implement the existing forest policy as laid down in Circular No. 22-F of the 19th October, 1894, with an addition the need for which has become more fully obvious of late, that one aim of policy ought to be to increase the area under forest (and preferably under Government forest) up to the minimum requirements of the country.

(*b*) In particular the principle of a sustained and equal annual yield from forests, which has actuated the Indian Forest Department since its inception in 1865, should be endorsed. To uphold this, the working plan position should be carefully examined immediately after the war to rectify any overfelling. The possibility of introducing a special working plans circle, where such does not already exist, should be examined.

(*c*) The land in each Province necessary for the preservation of the general climatic and physical conditions (*i.e.*, land subject to, or necessary for the control of, run off, floods, erosion or desiccation) should be defined and placed under proper management—probably in many cases forest management.

(*d*) It should be laid down as the aim of each province to have 20 per cent.—25 per

cent. of its area under forest and so distributed that the agricultural villager can obtain his needs for agricultural timber and fuel within a reasonable distance of his home.

(*e*) To obtain this ideal control of private forests will be necessary in most provinces. A Private Forest Act to legalize such control should be drafted. The act should legislate for various degrees of control depending on local conditions, but where necessary it should permit full management of the forests by Government. The present powers under Chapter V of the Indian Forest Act XVI of 1927 are insufficient.

(*f*) In most Provinces the area of forest under Government control is less than the safe minimum of 20 per cent. In some provinces large areas are devoid of any properly managed forest land, and there the majority of the village population cannot obtain their requirements of small timber and fuel and, perforce, burn cowdung. But in all these provinces there appears to be plenty of scope for increasing the forest area up to 20 per cent. or 25 per cent. and land for this exists properly distributed for the wants of the agricultural villager.

The basis of all this work is a classification of the land on the lines of the tables for cultivated and uncultivated areas in the agricultural statistics of India. That classification, however, is not made from the forest point of view and there is no doubt that much of the land classed as "not available for cultivation" could in fact grow trees and, properly regulated, could provide for better grazing. The classification should show :

Total area.

Cultivated area.

(*i*) Area actually sown.

(*ii*) Current fallow.

Forest land :

(*i*) Under the forest department.

(*ii*) Under other Government departments.

(*iii*) Private forest.

(*iv*) Mango groves, etc.

Uncultivated land (other than fallow) capable of growing fuel and small timber forests.

Uncultivated land not capable of growing fuel and small timber forests.

(*i*) Urban areas.

(*ii*) Roads.

(*iii*) Completely barren areas.

(*iv*) Railways, etc., etc.

Fuel and small timber can be grown on many areas often unproductive at present, like roadside land, canal banks, mango groves, railway land, etc., under quite short rotations of 15 years.

The above classification need not be particularly accurate for a start.

(*g*) The land management schemes decided upon must include the proper regulation of grazing. Excessive grazing is the cause of much land deterioration. Proper regulation increases the total available fodder and does not decrease it.

(*h*) The definition of the forest land recommended under (*a*) above, where land management must be such as to prevent floods and erosion, should be done for all other land in addition to forest land. It can be done concurrently with the classification of land recommended in (*f*) above. It is for consideration whether all Government land, the management of which is governed by the need to prevent run off and erosion, should be under the forest department. The answer to much of the flood and erosion problem in India is afforestation where possible, together with proper control of grazing, or, at any rate control of grazing, where afforestation is impossible or undesirable.

(*i*) It is especially important to grow forests on a percentage of the desert or low rainfall areas where irrigation is available, and to extend proper forest management wherever possible throughout the low rainfall area even where there is no irrigation. Forests can probably be grown without irrigation down to

somewhere within the 10-in. to 15-in. rainfall belt.

(*j*) It is recommended that a soil conservation, circle be formed in each province to deal with general land management and growing of trees in rural areas, whether it be to prevent run off, floods, erosion or desiccation or to supply the agriculturist with small timber and fuel. It is emphasized that, though it may take years before the full schemes are complete, the first results will be rapid. The full rotation of these minor forests will often be only 15—20 years and after 5 years the villagers will begin to get their first yield of fuel and grazing will be much improved. Where there is no serious frost, *Acacia arabica* (*babul* or *kikar*), is one of the most suitable trees except in very dry areas.

(*k*) It is recommended that the Central Government should appoint at once a Central Anti-Erosion Officer to investigate directly the problem of floods and erosion. He should be a forest officer working under the Inspector-General of Forests. It may later be necessary to expand this to a full Central Soil Conservation service.

(*l*) The Central Government is taking up more actively the general research in regard to valuable Minor Forest Products, but it is recommended that provinces should themselves investigate the needs of all industries depending on Minor forest products within the province. The Burma Government has already sent an officer to the Forest Research Institute, Dehra Dun, to be trained for this work.

(*m*) It is recommended that each province set up a local forest committee to draw up a post-war forest plan and that representatives of these committees then meet to correlate those details of their separate plans which apply throughout India.

(*n*) It is recommended that provinces send their gazetted officers trained at Dehra Dun for a continental tour in Europe between their second and fifth year of service. This recommendation is only a liberalization of a policy already existing in regard to selected forest officers.

(*o*) It is recommended that a commission be appointed as soon as possible to inquire into the best organization of the Forest Research Institute and that someone familiar with the internal working of the Institute and of the forest department in general be a member of this commission. The attention of this commission should be called to the present anomalous organization of the Utilization branch and to the need for a small central statistical branch to advise all branches on the design of experiments and to analyse the data recorded.

(*p*) The importance of training the Forester grade is emphasized and the Inspector General of Forests should inquire into the existing positon though it appears to be generally satisfactory.

(*q*) The present training of rangers is satisfactory and should continue as at present. It would be preferable, immediately it is possible, to move the Ranger College out to New Forest, but the old Ranger College should not be disposed of till the exact demands after post-war expansion are known.

(*r*) The Forest Research Institute should expedite investigation into the very valuable Minor Forest Products.

(*s*) It is recommended that the Central Government see that the release of Defence Department timber stocks after the war is controlled by the Disposal Board and that the forest department is adequately represented in any planning for such disposal. In connexion with this it is also recommended that in consultation with railways, steps should be taken to stabilize sleeper prices after the war.

6. The foregoing, though written primarily from the viewpoint of British India, is applicable almost in its entirety to the Indian States.

—*The Empire Forestry Journal*, Vol 24, No. 1, 1945.

A NOVEL METHOD OF IMPROVING THE GERMINATION OF *PROSOPIS JULIFLORA* SEEDS

By K. Kunhikrishnan Nambiar, B.Sc., (Ag.)

Assistant in Millets, Agricultural Research Institute, Coimbatore.

Prosopis juliflora, commonly known as mesquite or algaroba, is a tree recently introduced into this country. Its pods have a thick and spongy pericarp containing syrupy matter which is said to be of high nutritive value and is relished by all kinds of stock in America (Kunhi Kannan, 1928). On the karoo in South Africa sheep and goats are fed with the pods. Sometimes the pods are collected and ground to serve as cattle food. The tree is said to produce timber suitable for furniture and the flowers form a good honey-bee pasturage.

The Madras Agricultural Department has advocated the use of this plant for a live fence. It is suitable for this purpose as the seedlings make fairly quick and thick growth and are provided with sharp thorns. The plants are deep rooted and come up well with scanty rainfall. A considerable percentage of the seeds of *Prosopis juliflora*, however, are 'hard' or impervious to water under conditions favourable for germination. The following are the results of a few trials made at the Millet Breeding Station, Coimbatore, to find out an easy method of inducing germination in these hard seeds.

Prosopis juliflora belongs to the Leguminosae and in this family hard seededness is a common feature; it has been observed in nearly all its cultivated species (Harrington, 1916). Hard seeds that have remained impermeable even after continued boiling may be observed when most of the pulses are cooked whole. According to Rees (1910) this impermeability is produced by the laying down of fatty or waxy substances in the cuticle. Nelson (1926) is of the opinion that hardness is the result of the evaporation and deposition on the seed surface of the watery fluid surrounding the seed in the immature pod. Stutz (1933), however, observes that in alfalfa, seeds did not become hard coated while on the plant itself but that the condition set in only after storage.

Several methods have been tried to overcome hardness in seeds, particularly of clover and alfalfa. Among these, scarification or abrading the seed coat is a well-known method (Rees, 1910, Harrington, L. C. Stewart, 1926). In tea and *kolingi* (*T. Purpurea*) glass papering by hand has been recommended by Chandrasekhara Iyer (1940). To obtain the optimum degree of scarification as also to minimise the labour involved several machines have been designed and are in use particularly in America. Scarification, however, is likely to produce a varying percentage of damaged seedlings and also to reduce the longevity of the seeds in storage (Garaber, 1922). Application of dry heat has been tried with success in the case of alfalfa by Staker (1925) and Stewart (1926). Hot water treatment for overcoming hardness is mentioned by Rees, l. c. and Chandrasekhara Iyer, l. c. Midgley (1926) observed that hard seeds of alfalfa germinated when kept in a moist condition for several months. Busse (1930) tried freezing air-dry alfalfa seeds in liquid air (—190°C) and found that the impermeable seeds had become permeable. Alternations of temperature caused the softening of impermeable clover seeds (Harrington, 1. c. and Midgley, l. c.) Davies (1928) tested the effect of high pressure (2000 atmospheres) on impermeable seeds of clover and alfalfa and obtained increased percentages of germination.

Chemical methods aimed at breaking down the seed coat or dissolving the 'fatty', 'waxy' or 'varnish-like' deposition on the seed coat have been tried with varying amounts of success. Rees, l. c., tried chloroform, ether and hot alcohol, of which he found chloroform the best. Sulphuric acid has been tried by several workers in the treatment of hard seeds but mostly for the microscopic examination of impermeability.

A very interesting method for inducing permeability was discovered by Hamley (1932) who working with *Melilotus alba* (sweet white clover) found that light impacting in the region of the strophiole produced softening of the seeds. The simplest way of effecting this was by shaking the seeds in a bottle.

Of the various methods enumerated above scarification and impacting were chosen for trial with *Prosopis juliflora* seeds as being

likely to be simple and cheap if found successful. Sound, hand threshed seeds were used in these tests and the germinations were made in earthen pots filled with soil. Counts taken represent the number of seedlings that appeared above the soil surface. Table I gives the germinations obtained by different methods of injuring the seed coat.

TABLE I. Germination percentages of scarified seeds

Treatments.	4th day	5th day	6th day	7th day	8th day	9th day	10th day	11th day	12th day	13th day	14th day	Total.
i. Sand papered end opposite to radicle until cotyledons were seen	..	..	94	3	..	..	..	..	..	..	..	97
ii. Cut with knife on flat side ..	91	..	1	..	..	..	..	..	..	..	..	92
iii. Made small scratch with sand paper ..	88	2	..	1	..	..	..	..	..	..	..	91
iv. Pounded with sand	79	6	1	1	..	..	..	..	..	..	..	87
v. Rubbed on Cuddapah slab	72	8	1	..	1	..	1	..	..	..	1	84
vi. Untreated	1	14	13	6	6	5	1	..	3	1	..	50

It will be seen that all the treatments have given satisfactory germination. In *i, ii* and *iii*, however, the seeds have to be individually treated and therefore these methods cannot be recommended except for very small samples. For larger quantities of seed, pounding with sand would appear to be the most practical way of scarifying the seed coat for improving the germination.

The results of impacting seeds of *Prosopis juliflora* are given in Table II. As in the scarification experiments sound, hand-threshed seeds were used. Samples of 100 seeds were put into an eight-ounce bottle and were shaken vertically at the rate of twice per second.

TABLE II. Germination percentages of impacted seeds

Treatments.	4th day	5th day	6th day	7th day	8th day	9th day	10th day	11th day	12th day	13th day	14th day	Total.
i. Shaken for 1 minute	..	7	8	16	13	..	..	..	8	10	2	64
ii. ,, 3 ,, ...	..	27	13	17	3	..	..	..	11	3	4	78
iii. ,, 5 ,, ...	..	45	21	7	9	2	4	1	3	..	1	93
iv. ,, 10 ,, ...	..	56	28	6	5	1	..	1	..	..	..	97
v. ,, 15 ,, ...	..	68	19	7	2	1	..	..	..	..	..	97
vi. Untreated	..	14	15	6	10	9	2	2	2	2	..	60

It will be seen from Table II that shaking the seeds for ten minutes or more has resulted in rapid and satisfactory germination. The 15-minute treatment was repeated with one pound sample of seed put into a square tin and shaken at the same rate. The germination obtained was 95 per cent. within a period of one week. The response of *P. juliflora* seeds to impacting is thus very similar to that of *M. alba*. The hard seeds present in the samples of *P. juliflora* have evidently softened as a result of the impacts received in the shaking. No attempts were made to discover the mechanism of this softening; however, a brief summary of the findings in *M. alba* may be of interest.

Hamley, l.c, found that it was possible to distinguish permeable areas on the seed coats

of clover and alfalfa by a short treatment with osmic acid. It was observed that in soft seeds whose coats have not been injured, absorption of water took place through the strophiole. By histological examination he was able to show that in hard seeds the strophiolar cells are in a state of tension which when upset produces softening through a split occurring between these cells. It was conjuctured that this fracture could be produced by a small impact in the neighbourhood of the strophiole. For this purpose it was not thought feasible to tap every seed in the strophiolar region individually, but if the seeds are thrown about in a hard container, softening would occur if a sufficient number of impacts are given so that one blow at least would strike at or near the strophiole.

It would be interesting to find out if hardness occurring in our common leguminous seeds can be overcome by this method, and if so whether the mechanism of softening is similar to that in *Melilotus alba*.

Summary.—Poor germination in *Prosopis juliflora* seeds is due in part to the occurrence of 'hard' or impermeable seeds. In the samples tested, over 40 per cent. of the seeds failed to absorb water. It was found that this could be remedied by shaking the seeds in a metal or glass container for about fifteen minutes at the rate of twice per second. Seeds so treated gave over 95 per cent. germination. Abrading the seeds by pounding them with sand was also found to be a successful, but less easy, method.

Acknowledgement.—My thanks are due to Sri C. Vijayaraghavan, Millet Specialist, under whose guidance this work was done.

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—*The Madras Agricultural Journal*, Vol. xxxii, No. 8, 9 & 10, August, September and October, 1944.

POST WAR FORESTRY TRAINING CENTRES.

C. P. Ackers

(*Note.*—The following memorandum was prepared as a basis for discussion at a meeting of the Executive Committee on February 22, 1945. In view of its importance the Committee ordered that it should be published in the *Journal.*)

I have been asked to prepare some suggestions to put before the Executive Committee to be held on 22nd and 23rd inst.

As I visualize the position, we cannot attain to anything like the ideal we could wish for, because of certain fundamental handicaps that cannot be immediately overcome; these are as follows:

(1) The Government Forestry Service has to date been unable to spare any appreciable number of its officers for anything more than the shortest periods to help private forestry

either from the educational or advisory sides. With the greatly increased post-war programme they envisage for State forestry alone, it seems hopeless to look for help from this source.

(2) The number of highly trained theoretical foresters, either at our Schools, Colleges and Universities, or in private practice, is very limited. In addition to their essential work of research and normal teaching, they have the Colonial Services to cater for as well as the home demand.

(3) Institutions where full theoretical forestry training can be obtained are also sadly limited, even where there is a bigger teaching staff available.

Consideration must be given to (A) the class of renovation work we have immediately before us; (B) the number and type of men we require for this work; (C) the question as to whether practical training should follow, proceed or be interlocked with theoretical training.

It seems essential to plan for the immediate future for a definite but comparatively short number of years. I consider that a five-year period after the cessation of hostilities should be given to private owners to plan and commence to put their woodlands into order; also that a similar period should be taken for the training scheme we have in view. I now take my three considerations set out above in detail.

(A) *The renovation work immediately in front of us.*

Plantations too young to yield appreciable quantities of pit timber will require brushing up and thinning. There will probably be an almost unlimited demand for the produce that can come from them. It is not so easy for an inexperienced forester to spoil such plantations as in the case of plantations that are in need of their second or third reasonably heavy thinnings. Sound grounding is, however, essential, so I recommend for this that as many estates as possible throughout England and Wales that possess a sound forester and areas of such plantations should be asked to take one, two or at the most three pupils at a time. One month's training should be enough if practice in marking thinnings only is in view; longer, however, would be desirable if this is combined with the practical work of brushing up, cutting and extracting such thinnings.

The main work will, however, be (1) clearance of ground vegetation, lop and top, scrub, etc. in preparation for planting; (2) the building up of estate nurseries, as many will wish to buy in seedlings from the trade and grow their own transplants; (3) the planting up of our devastated areas together with the fostering of natural regeneration on some of them.

(B) *Number and type of men required.*

A working forester can look after anything from 500 to 1,000 acres of woodland. There will be upwards of one million acres throughout the country to renovate if we include the land that was devastated is 1914—18 and never replanted. Some is in Scotland, some will be required by the State. There may be enough trained men in the country to get on with a quarter or one-third of this work when those younger ones that are spared return from the Forces, but this will leave some 500,000 acres in England and Wales to be renovated; for this we are faced with the necessity of training between 500 and 1,000 working foresters; let us say, 750 new trainees of the working forester type to be turned out in five years. We shall have to plan for a certain number of trainees either not reaching or passing the working forester standard. Say 10 per cent. will find they do not really settle down to the work, or do not reach the required standard; we need not estimate for more than this, because all candidates will have to be carefully selected. Say 15 per cent. are found to be good and ambitious enough to aim straight away at higher posts in our forestry world. Then we must start with 1,000 men, expecting 100 casualties, 150 going towards the higher grades, with 750 remaining out of our 1,000 for our main little army of working foresters. That means 250 men a year for four years, to be trained by the end of the fifth year. Now we can surely find sufficient estates throughout England and Wales where from one to four pupils could be taken under a sound forester: if 20 such places could be found they could train 50 out of our 250 yearly pupils. That leaves 200 to be placed on estates that can take from 15 to 25 pupils at a time, say an average of 20, so we shall require ten main centres; of these, three might well be situated in Wales (one in northern, one in central and one in south Wales), leaving seven centres for England. There would probably have to be considerable shifting about of these pupils from one centre to another, for one might well specialize in sawmilling, another in nursery

work; then pupils could take special four to six weeks' courses at such centres, returning to their own centre when such short courses are completed.

(C) *The relative position of Theory and Practice.*

A sailor is never made by being given a three-year theoretical course and then suddenly pushed out to sea in command of a ship. An airman's training from the outset has some practice in it and practice plus theory are mixed steadily throughout training. The agricultural student who has passed first in his year in theory but has never milked a cow or successfully driven machinery behind a tractor makes a hopeless farmer nine times out of ten. The failures in men going from theory to practice (the hard business of making money out of woodland operations) have been due to the wrong education that has to date been given from our Forestry Centres of learning. Basic fundamentals are never taught, such as handling men sympathetically; the fact that they will mix with practical workmen who know much of the essentials better than they themselves with all their theory ever will; the essential value of costings, costings all the time, costings in minute detail; costings for every type of operation. I am, in consequence, absolutely convinced that practice must come first, that with no theory at all we can make some real success of forest ventures, with no practice at all we should make failures, but with both judiciously blended we shall achieve our real goal. This has been my firm conviction for many years and I personally had five and a half years' theory with too little practice after my school days.

I am absolutely convinced in my own mind that we have enough practical foresters in the country willing and able to give the advice necessary for the establishment of the best types of pure plantations or mixtures suitable for renovating our woodlands. Also that having such advice available we should concentrate at the outset on the practical side and train men from the Forces in the use of a spade, a billhook and an axe. This means that our first work should be to train gangers and working foresters in the practical side of their work.

If forestry and agriculture are not to become sadly estranged, as has already been the case under certain aspects of State forestry, this education must take place on private estates under authority that has sympathy and understanding between the two branches of land cropping, the ideal being estates where extensive home-farmlands are run in co-operation with the woodlands or where the woodlands cater strongly for local agricultural demands.

Taking into account, therefore, the disadvantages under which we must work, as well as the general programme we have in view, I feel that our goal should be to get as many suitable estates as possible to take one or more pupils at a time, as well as to form at least eight main centres (two for Wales and six for England), where from 15 to 25 pupils can be accommodated at a time for a nine to twelve months' practical course; we shall be dealing with some men who "feel" that they would like to take up forestry as a career, but who really cannot be certain that it will suit them until they have tested out the practical living conditions and contacts with woodlands: it is useless to start such men on theory only. It has been found at Oxford, as well as at our best agricultural colleges, that previous personal practical contact with the subject is a very great help in the ready absorption of theory; one year's elementary grounding in the sciences followed by one year's practical work (two is better still), followed then by one year's advanced theory, seems to give excellent results. Now if we preface this training at our estate centres with twelve months' practical work, during which we encourage correspondence courses in forest theory, also during which some lectures are given, we should get good results. We should eliminate a few to whom the work did not really appeal, we should train sufficiently well a number of useful gangers and working foresters, we should also have the chance to select a number of the more promising and ambitious men for further training. The lectures above referred to would come as far as possible from the best members of the university and college staffs who should be allowed by their authority to pay occasional visits to our estate centres. Further lectures could be given by professional foresters who are in private practice and in this connection our Society might do very useful work in organizing and contributing towards the expenses of these professional men.

Those trainees who were selected for advanced training could then go to existing centres of learning for elementary grounding in the sciences, put in further advanced practical

work and finish off at Oxford or some other existing centre where specialist courses in forestry as particularly applicable to English conditions could be taken. At the end of our fourth year we should then be getting our first batch of fully trained forest officers; intermediate standards of efficiency between them and our one year trained gangers and working foresters could be aimed at to give intermediate grades of foresters after two or three years' training.

Scholarships and bursaries should be given to the most promising candidates, who should be selected on account of (1) the efficiency of their war service; (2) their promise shown at the estate centres; (3) their keenness to get to the top of their profession.

Special training should be given to selected candidates to train them up as teachers of practical work. It is as hard for a man who is filled with theory only to teach sound practical work as it is for the highly efficient practical man, who has been brought up from boyhood in the woods, who has been born with an axe in his hand, to explain how he does his work; these skilled craftsmen do not know really how they do things and have not the broadness of education to know how to teach. The supply of intelligent men trained in both theory and practice, with an aptitude for teaching, must be one of our main goals.

These estate centres must have facilities for practical work in:

(1) timber extraction (the most difficult side of practical forestry);
(2) sawmilling and general conversion;
(3) carpentry, with special facilities for gate making;
(4) ladder making and/or wheelwright work;
(5) hedge laying and/or dry stone walling; as well as, where possible, the details of;
(6) underwood and pure coppice conversion, together with such subsidiary trades as
(7) hurdle making;
(8) forest nursery work, together with, if possible, some knowledge of choice nursery stock.

—*Quarterly, Journal of Forestry,* Vol. XXXIX, No. 2, July 1945.

NEW WOOD PRODUCTS IN OUR FUTURE ECONOMY *

Geo. W. Trayer

Chief Division of Forest Products, U. S. Forest Service, Washington, D. C.

This paper deals chiefly with two groups of new wood products—(1) those in which the wood has been modified by mechanical or physical means, and (2) those in which the wood has been converted by chemicals or heat into some enitrely different form. The author believes that these new products will supplement rather than replace such standard products as lumber, veneer, and pulp, and stresses the dependence of all of the wood-using industries upon continuous, balanced production of the wood crop from managed forests.

Such a group as that assembled here tonight is undoubtedly in full agreement regarding the desirability of getting forest industries upon a permanent basis, getting them geared to the productive capacity of our forest land, and utilizing all the various species and qualities of timber available, including the vast quantities of waste material now common in forest conversion. In considering the capabilities of new wood products to contribute to such a program, I wish first to point out that, in my belief, we are only on the scientific frontier of forest utilization. Our utilization up to now has been more or less opportunistic, unbalanced, and poorly integrated. For the most part, the harvest has been directed toward manufacture from comparatively few species, and too much toward the production of lumber or some single product. Such utilization leads to overcutting and culling of forest stands and the conversion of productive forests to idle lands or non-productive forests.

Proper utilization, developed through research and the industrial application of results, requires the development of new methods of conversion that will transform into useful goods all the

* Presented at Conference on New Developments in Wood Products, New York State College of Forestry, Syracuse University, October 6, 1944.

wood crop, including the present huge piles of sawdust and the shocking volumes of wood left at the mills, in the woods, and even on the stump. Such utilization can obtain values from the forest crop far in excess of those in present or past experience, and at the same time result in greater growth and better balanced and more useful forests. This type of wood conversion, made possible through reasearch, should lead to the establishment of permanent wood-using industries, geared to the productive capacity of our forest land, which as I said at the start is our objective.

Coming back now to the main topic of my discussion—new wood products which seem to offer promise of contributing to such a program—I wish to limit myself to the second and third of three broad classifications of wood products. In the first category there would fall all those products in which wood is used more or less in its natural form or state. Second, there is a group of products in which the properties of wood have been modified by various chemical or physical treatments in order to enhance their usefulness for a wide range of purposes. Third, is a group of chemically converted products, or products of wood phyrolysis.

Direct Wood Products

In the first classification would be included the development of improved box and crate construction, which has meant so much in this war and would be a subject in itself. Glued-laminated structures was the subject of two papers this afternoon. New developments in gluing, preservation, fire protection, and painting all have an important bearing upon future wood products and our ability to use to the fullest all of the forest crop.

Undoubtedly this will continue to be the biggest over-all industrial use of wood, and only the limitation of time prevents a fuller discussion of this field. Suffice it to say that wood must maintain its place in those normal fields constantly contested by old materials refined by science and by new materials of scientific origin. In short, in the field of wood as wood we must keep abreast or ahead of the rapidly developing technology of materials. Our discussions so far at this conference would seem to indicate that we are doing pretty well.

Modified Wood Products

Let us turn now to the second field, in which wood has been modified by chemical or physical means. The inherent valuable properties of natural wood have been vitiated to a certain extent by its tendency to shrink and swell under variable moisture conditions. Recently considerable attention has been given to overcoming or reducing this tendency. At first glance, the obvious solution would appear to lie in merely plugging the pores and open spaces in the wood with materials that are not wetted by water. Waxy and paraffin-like materials could readily be applied by impregnation under pressure in a molten condition or by diffusion while in solution and the solvent later evaporated. The net result was only a slowing down of the rate of swelling or shrinking. The affinity of the internal surfaces of the wood for water was not altered; the action was the purely physical one of slowing but not stopping the absorption of water.

Advancement in this field and the development of new, modified wood products became possible, however, with the development of synthetic resins. The components of these resins are introduced into the wood in solution and then formed into resin by heating the impregnated wood. We call this product "impreg". The small size of the molecules of the components of the resins permits complete permeation of the wood structure and the chemicals themselves react with the wood's internal surfaces, thus decreasing its affinity for water. Using this process, the swelling and shrinkage of wood is reduced to only 20 or 30 per cent. of normal with attendant improvement in some of its properties.

An extension of the impregnation process yields a product with greatly improved properties. The chemical reaction which I have just described was accomplished by heat. It, however, is accompanied by plasticizing of the wood which makes it compressible under relatively low pressures. Then when both heat and pressure are applied after impregnation a product is formed which is called "compreg." "Compreg," in addition to high strength properties and fine finish, has a water absorption which is so low as to be almost negligible. Its strength is proportional to the degree to which it has been compressed, but strength-weight ratios of the order of light-metal alloys are obtainable. It is of importance to note that "compreg" can be made from woods of any original density from balsa to maple. While it appears that phenol formaldehyde resins do the best job of improving wood properties by this method, some

others are cneaper and yield good products. The field of other impregnants is being explored, and doubtless chemists will turn up new and better materials. It is probable that lignin itself, derived from wood, may become a source of resin for impregnation.

A cheap and fairly effective method of increasing the strength and dimensional stability of wood appears to be that of taking advantage of the fact that wood is plastic to some degree and compressible when heated to temperatures just below charring. The process consists of heating a piece of wood under controlled moisture content to a proper temperature and compressing to a desired density. The product is called heat-stablized compressed wood, or "staypak," for short. While other properties are increased as in the case of "compreg", this material has unusually high toughness.

As I have pointed out, the principal effect of impregnation treatments is to alter the chemical nature of the internal wood surfaces so that they no longer have an affinity for water. But it appears that the internal surface of wood is altered by high temperatures. It has been found, for example, that wood heated to temperatures just short of charring for a brief interval by passing it through molten metal decreases its tendency to shrink or swell by some 40 per cent. In this "heat-stabilized wood" some progress has been made in modifying wood to eliminate or reduce its tendency to change dimensions.

It has long been known that the permeability of wood to gases offers an opportunity to penetrate it with reactive materials. Some progress is being made along this line and has led to a material called "acetylated wood." To make this material, wood is treated with the vapours of acetic anhydride to block the hydroxyl groups that are responsible for water absorption.

In this whole field it appears that considerable progress has been made in modifying wood to eliminate or reduce one of its least desirable properties, shrinking and swelling, while enhancing its more desirable properties. The field is young and susceptible to much productive exploration. It will continually have to be re-explored as progress is made in chemical fields that develop new impregnating materials.

Converted Wood Products.

Let us take a look now at the third broad classification, which may be referred to as converted wood.

Wood is the base for the thousands of products we use every day made from pulp or paper, and for a rapidly growing textile and fibre industry. To the thousands of forms of paper already in use there is added a new one potentially capable of absorbing great quantities of pulp I refer to high-strength paper laminate, called "papreg" for short. This is a laminated paper plastic similar in its properties to compreg Many sheets of paper impregnated with the components of phenol formaldehyde resin are pressed together under the application of heat and a very hard, strong product is obtained. Paper laminates treated with phenolic resins have been made for years. They were used chiefly for non-structural purposes, and in developing them attention was chiefly directed to the resins. Directing attention to the character of the paper used has led to paper-base laminates possessing several properties double those of former laminates.

Somewhat similar paper laminates have been made by impregnating the paper sheets with lignin recovered from the alkaline pulping processes. These "lignin-filled paper laminates" are new and their fields of applicability have not yet been determined, but they look promising. Most strength properties of such laminates do not approach those of "papreg" except in toughness, but they should be cheaper.

Legnin is nature's plastic in wood which cements the cellulose fibres together. If by a mild hydrolysis the bond between cellulose and lignin is broken, the freed lignin can be used to rebond the cellulose fibres together. That essentially is what is done in making "hydroxylin," except that in breaking the bond with a dilute acid treatment the hemicellulose is converted to sugar. These sugars with the acid are washed out of the hydrolyzed wood, leaving a residue constituting 50 to 60 per cent. of the weight of the original wood. After drying, the hydrolyzed wood is ground to a powder. With the addition of a small amount of auxiliary plastic-forming constituents, this hydrolyzed wood has good moulding characteristics to form products with good water resistance, acid resistance, and electrical and mechanical properties. Incidentally, the washed-out sugars formed in

the hydrolysis may be fermented to alcohol, giving a valuable by-product.

As was pointed out this afternoon by Mr. Carl Rishell in his discussion of wood waste, the largest potential field for the utilization of wood as a raw material for the chemical engineering industry at present is offered by its conversion through hydrolysis to sugar and lignin. It was long ago determined that wood could be treated with acids under conditions of relatively high temperature to effect a transformation of the celluloses and the hemicelluloses to simple sugars. A process for the manufacture of ethyl alcohol by the fermentation of wood sugar produced by one process of hydrolysis was developed during the first world war. Since then, up to very recently there has been great improvement in wood-hydrolysis technique. I am not going to dwell upon these improvements. Suffice to say that it now appears that 50 or even more gallons of alcohol can be produced from a ton, dry weight, of softwood. If a synthetic rubber industry continues after this war, it will use as its raw material probably either alcohol or petroleum, or the national interest may dictate the use of both. This would seem to offer a large potential outlet for alcohol from wood sugar, to say nothing of the possibility of its use for motor fuel. There is still another source of synthetic rubber being developed. This is the fermentation of sugar to 2, 3-butylene-glycol and the manufacture of butadiene and rubber from this material. Whether a rubber program calls for alcohol or 2, 3-butylene-glycol, the base is cheap sugar. If wood sugar is sufficiently cheap, its use will be found economically desirable.

I would now like to dwell briefly on lignin, which is produced as a by-product of wood hydrolysis. From each ton of dry wood there is obtained 500 to 600 pounds of lignin, a brown powder that seems to offer possibilities of becoming a wood product of considerable importance for chemical utilization. There are two principal lines of research looking toward the utilization of lignin. In the first place, it must be remembered that lignin is a sort of shotgun term that applies to an indeterminate mixture of substances, the composition of which is widely variable according to the methods used in the preparation of lignin. Thus lignin from sulfite pulping is an entirely different material from lignin that is a by-product of the Scholler process of wood hydrolysis.

For the moment I am going to confine myself entirely to lignin as a product of wood hydrolysis. There are two major lines of research looking toward its realization, one dealing with the use of lignin itself as a plastic, a plastic extender, an ingredient of acid-proof durable coatings, a binder, or other fields that make use of the resinous plastic character of lignin. It must be admitted that Scholler lignin itself is not a very promising plastic former. But these other lines may develop uses for the material that will in the aggregate require considerable quantities. The second major line of endeavour perhaps more promising from the point of view of the possible establishment of chemical industries requiring large amounts of raw material, is the transformation of lignin into chemical goods. Among the most promising lines is hydrogenolysis, the comparatively simple treatment of lignin under pressure with hydrogen in the presence of an appropriate catalyst. Briefly, varying the conditions of the reaction and the catalyst, there have been obtained wide ranges of products that are only inadequately characterized. Suffice it to say that among these products are the familiar phenols and cresols that are important ingredients of those waterproof resins finding such wide application in other forest products fields, an excellent yield of methyl alcohol, the base for the formaldehyde that is the other of the materials principaly used in the formulation of waterproof resinous glues, and a whole host of other materials in good yields that are so new that we cannot yet predict the uses that may be found for them. It should be emphasized that the principal product of the reaction is a heavy oil, the composition and character of which has not yet been determined, but it is known that it is principally hydrocarbon in its nature and there seems to be no great technical obstacle to its cracking and resynthesis into hydrocarbon motor fuel. At least this line will be followed.

If the wood hydrolysis industry develops into an industry of considerable magnitude, the production of the lignin by-product will be enormous. It is apparent, therefore, that outlets for the material must consume huge tonnages. Small specialty products will not meet the requirements of tonnage consumption. Perhaps hydrogenolysis may develop into a chemical industry that will require a lot of lignin. There is still required, however, some simple outlet for lignin that will take all that may be produced at perhaps a low-cost figure. Just what this

product may be cannot be determined at this time. We are interested in the application of lignin as a possible fertilizer. Certainly if it could be developed into a fertilizer ingredient of value, this field would take all that we might produce.

Conclusion

In conclusion may I again emphasize the fact that all these new and modified products of wood do not contemplate much slackening of the demand for and usefulness of lumber. In fact, they all depend upon continuous, balanced production of the wood crop from managed forests, because cheap wood waste can only arise from basic wood-using industry dependent upon sustained yield forestry for its raw material. Chemical industry dependent upon wood can only live on very cheap and abundant wood. Very cheap and abundant wood can only come if such products as lumber, veneer, and pulp bear the major part of the cost of growing trees. It is unwise, in my opinion, to think of these potential waste-conversion industries as being capable of bearing more than a small fraction of the total cost of a forest program.

Journal of Forestry, Vol. 43., No. 3, March, 1945.

VOLUME 72 NUMBER 5

INDIAN FORESTER

MAY, 1946

AERIAL RECONNAISSANCE FOR FOREST OFFICERS

BY A. L. GRIFFITH, I.F.S.

(*Central Silviculturist, Forest Research Institute, Dehra Dun*)

Much has been said in the past of air reconnaissance and air photos of areas which are difficult to deal with by ground parties, but little has been done in practice. The subject was again referred to at the sixth silvicultural conference a year ago, when one delegate while discussing the possibilities of sampling enumerations in difficult country said, "With regard to the distribution of the enumeration lines over the area so that the different forest types may be sampled to the same, or shall we say, an appropriate extent, I would suggest that much more use might be made of aerial photography and reconnaissance to obtain an idea of the broad distribution of important forest types over the area to be sampled, so that the general layout of the sample grid would be easier."

A great deal of very accurate aerial photography has been carried out in India and Burma during the war by both the R. A. F. and the American Air Force, and we should make full use of the work they have done as far as our forest areas are concerned.

Many areas are difficult and tedious to get to. Some are difficult to traverse on the ground and have very poor visibility, while others in addition, are very unhealthy. Such areas are often not worth the time, labour and expense of a ground party.

Accurate air surveys need a very special *bandobast* and a highly trained staff with special equipment. They are necessarily fairly expensive, and not easy to organize. In consequence, most forest officers hesitate over the very idea.

I have recently been on a fairly extensive tour of the Thar desert of Sind, and as some parts of it that it was necessary to see could not be reached by ground travel in a reasonable time, we decided to go by air. I had never even tried to take an air photo before, so decided to have a crack at taking some with an ordinary camera, and with no special equipment at all. It was thus the most amateur attempt at air reconnaissance and photography that could be done, but the experience gained, and the photos that resulted have given an admirable indication of the sort of results that can be obtained by the ordinary forest officer. It is this that has prompted me to record in this article just what was done, as it will, I hope, be of interest to readers.

The Thar desert of Sind is the south-western part of the Great Indian desert, and is some 10,000 square miles in area. It is bounded in the west by the Nara river, in the south by the Rann of Cutch, and on the north and east by other parts of the desert. I hope to give a brief description of the formation and vegetation of this most interesting area in a later article, but it suffices to say now that the general formation is by sand blowing from the Rann of Cutch in a SW/NE direction. The desert is very well covered with vegetation except where local overgrazing has caused the disappearance of ground cover and started sand, that had been fixed for centuries, on the move again.

The tour was arranged by Mr. E. A. Garland, the Conservator of Forests, Development, Sind, and in the month our little party travelled some 200 miles by camel and saw a fair amount of the westerly edge of the area from Naukot in the south, to Chhor in the north, penetrating some 30 or 40 miles into the desert itself. I also travelled by goods train from Chhor to Khokhropar. This is a distance of some 35 miles due east across the desert to the Sind-Jodhpur boundary and gives an excellent section of the desert.

It was very obvious that the tour would be incomplete without seeing the more southerly and easterly parts of the area, mainly towards Nagar Parkar on the edge of the Rann of Cutch, from whence the general sand drift starts. To get to this area by land, would mean one day by train and then some seven or eight days each way by camel, exclusive of days spent on inspection. Great detail was not wanted and a general reconnaissance was all that was necessary, and hence the obvious solution was to do it by air. The Government of India and the Government of Sind agreed, and in consequence, after one month of arduous camelling, we returned to Karachi and organised the visit from there.

The trip consisted of a charter flight in a Gipsy Moth plane, arranged by the Karachi Aero Club, Ltd., and piloted by the club's chief pilot Major Jones who was exceedingly helpful throughout.

For the benefit of those unfamiliar with this type of plane, the Gipsy Moth is an old fashioned, small, light, two seater biplane. The two seats are one behind the other, and I sat in front with the pilot behind. The seat is open with a windscreen in front and side flaps up to shoulder height; these were let down to waist level for taking photographs. Vision was good practically all round, though photography in front meant pointing the camera through the wings. I took two cameras, one a 9 cm. $\times$12 cm. size folding Zeiss Ikon with a film pack adapter, and the other a Rolliflex using a $2\frac{1}{4}\times2\frac{1}{4}$ inch roll film. To take a photo, one has to lean right out into the wind, and the camera or exposure meter must be strapped on, as the wind is liable to tear it out of one's hands. This would not only mean the loss of the camera, but might seriously damage the tail of the plane.

We took off from Karachi and flew direct to Chhor, where we landed at a temporary air strip and refuelled. From here we went along the edge of the desert to Umarkot, and then right across the desert in a general S. S. E. direction towards Nagar Parkar and the Rann of Cutch, passing over Chelhar and Mithi which I had seen on the ground earlier in the month. When we hit the northern edge of the Rann of Cutch we turned west and followed the edge of the Rann to Rahim Bazaar, where the cultivation, the desert, and the Rann all meet near the Nara river. From there we flew back to Karachi across the delta of the Indus, with its mud flats and mangrove swamps. The total distance flown was about 450 miles. The general cruising speed was about 75 m.p.h. During the whole flight the pilot took me exactly where I suggested I wanted to go, and we zigzagged about to look at and photograph anything of interest which appeared. It was thus not just a straight flight from one place to another. The passage was generally smooth, but we did strike some very bumpy patches indeed.

It was very quickly obvious that the larger camera was too bulky and awkward to use, and in addition, the wire square sighting was very difficult to get clear. The smaller Rolliflex, with a single direct sight, was very convenient. This sight consists of a hollow square containing a frame, in the middle of which is a small mirrored lens with a hole in the middle. All one has to do is to see one's own eye reflected in this little mirror to know that all one can see in the hollow square is in the picture. One must also realise that taking photos in this way is very different from doing so on the ground. Wearing a flying helmet and goggles greatly reduces one's sensitivity, and also the wind and the engine noise prevent one hearing the winding of the camera or the click of the shutter working. A great advantage of the Rolliflex was the automatic winding which ensures that the film is wound on the correct distance for each exposure.

The day was clear with good visibility. Varying heights were tried, and 500 feet to 1,000 feet turned out to be the most suitable altitude under the conditions of this particular trip. I used an ordinary standard Weston exposure meter, and with apertures of F. 8 to F. 11., and using a heavy yellow filter, exposures generally varied from one-fiftieth to one-hundredth of a second. The film was Kodak Super XX high speed panchromatic.

In plates 7 to 10 are shown eight pictures to demonstrate the sort of detail that comes out. Two of the photos (*Fig.* 1 *of plate* 7, and *Fig.* 5 *of plate* 9) were taken on the ground, and are shown to illustrate the difference between ground and air photos of the same details.

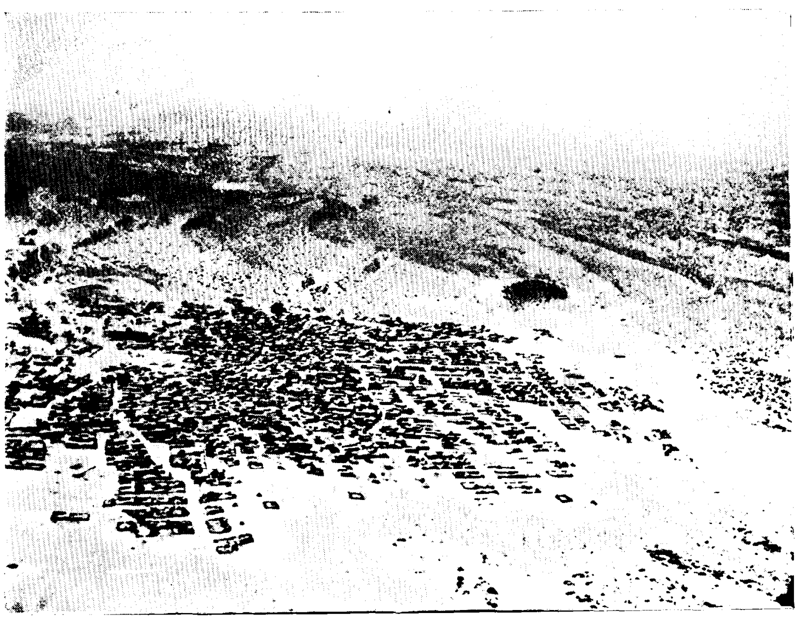
This flight amply demonstrated the value of air reconnaissance. I saw roughly four times as much of the desert in a few hours, as I had seen in a month by camels on the ground, and it showed the problem as a whole. On

Fig. 1

Typical desert scenery. On the hills are **Acacia senegal, Prosopis spicigera** and **Euphorbia neriifolia** while in the hollows are **Capparis aphylla, Salvadora oleoides, Aerua tomentosa, Crotalaria burhia,** and some **Calligonum polygonoides.**

Photo : Author.

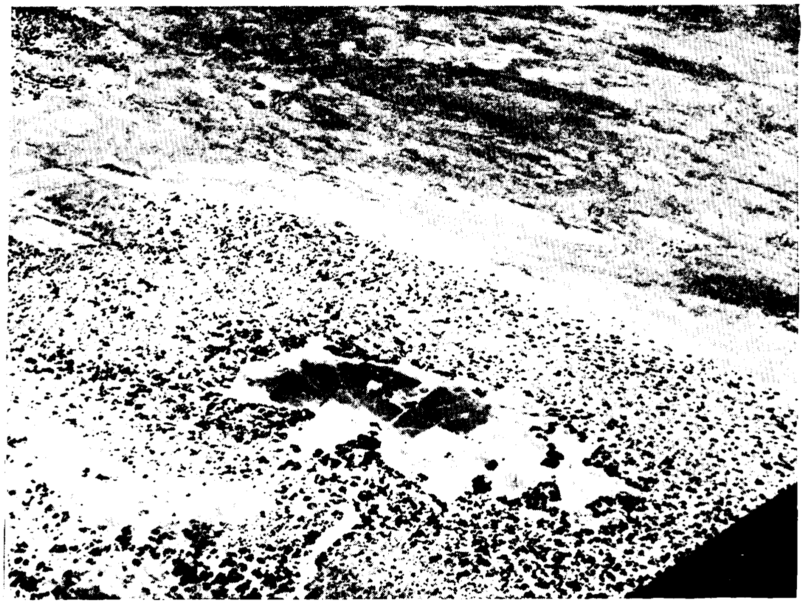
Fig. 2



The desert town of Mithi. Note the drift sand on the right hand side which is endangering the town. It is caused by local overgrazing of the sand hills behind the town.

Photo : Author.

Fig. 3



A patch of cultivation on the edge of the desert where it borders the Rann of Cutch. The change from desert to Rann is abrupt and there is no transition area. The tree growth is chiefly **Prosopis spicigera.** Note that the ground vegetation of **Aerua tomentosa** and **Cortalaria burhia** seen in Fig. 1 in a ground photograph hardly shows in an air photo as both species are nearly the same colour as the sand.

Photo : Author.

Fig. 4

The western edge of the desert between Chhor and Umarkot. The change from cultivation to desert is abrupt and there is no transition area. The tree growth is chiefly **Prosopis spicigera, Acacia senegal** and some **Azadirachta indica.**

Photo : Author.

the ground one sees each item as an entirely local problem, and tends to get little idea of the whole picture.

It has its disadvantages however. For example, from the air one does not realise the height of the sand hills which often go up to 250 or 300 feet. If I had not been on the ground previously I should also have got a false impression of the vegetation, because two of the main low species, *Aerua tomentosa* which was in flower, and *Crotalaria burhia,* are nearly the same colour as the sand and from the air one scarcely notices them. They also hardly show in the air photos, whereas they are very conspicuous on the ground. (*vide Fig.* 1 *plate* 7, and *Figs.* 3 *and* 4 *of plate* 8). The greener and higher growth such as *Prosopis spicigera, Acacia senegal, Capparis aphylla* and *Salvadora oleoides,* is quite easy to recognise from the air.

In Figs. 3 and 4 of plate 8, and Fig. 7 of plate 10 the demarcation of the Rann of Cutch, cultivation in the desert, cultivation beyond the desert, salt deposits, roads, camel tracks, tree growth, etc., all demonstrate how much information can be gathered from such an air reconnaissance. The photos of course, are all obliques and cannot easily be used for map making, but from them rough stock mapping to types, etc., is clearly possible.

Fig. 2 of plate 7, gives a good idea of the general drift of the sand which is threatening the north-eastern side of the town of Mithi. This is clear on the ground also, but one gets little idea of the real extent of it.

Figs. 5 and 6 of plate 9, show a village from the ground and from the air, and it is of interest to note how clearly the individual huts and the thorn hedges of *Capparis* that surround them, show up from the air.

Fig. 8 of plate 10, is rather deceptive. It was taken from about 2,000 feet altitude, and shows where the Nara river enters the Rann of Cutch. Although the picture appears to be a wet waste, yet in reality there is practically no water in the picture at all. The Nara itself at the time was the merest trickle, and the rest of the picture is a dreary waste of drifting sand, with salt patches in it.

I would emphasize that an air reconnaissance of this sort is complementary to, and not a substitute for a ground inspection. It is essential to see the desert on the ground before seeing it from the air, in order to get a correct impression. My point, is, that a short ground survey, followed by an air trip, gives information that otherwise would have taken months and months to collect on the ground. Another score is that of expense. The entire flight cost only Rs. 250. To have covered the same area on the ground not only would have taken a long time, and would not have given as much information, but it also would have cost considerably more.

Another point that this flight convinced me of, is that to study any erosion problem, whether of a small or of a large area, an air reconnaissance is essential. In the first thirty miles or so of the journey from Karachi to Hyderabad by road, erosion, although obviously present, does not appear to be acute or particularly serious. Seen from the air the whole country is completely cut up by *nullahs* and gullies all the way from the Baluchistan foothills, and the position is obviously very serious indeed. Unfortunately I did not take any photos of this area as I was saving my pictures for the desert.

In conclusion, I hope that this article will urge forest officers, and particularly those dealing with such problems as working plans, erosion schemes, reconnaissance of new areas, etc., to have a look at their country and problems from above. I can assure them that it will give them new ideas, and a far more complete appreciation of their problems.

I would like to take this opportunity of thanking Mr. Garland for the trouble he took in making the arrangements for this tour and flight, and Major Jones the pilot, for his great co-operation and help. In addition, I would express my appreciation of the farsightedness of the Government of India, and of the Government of Sind, in approving of this somewhat unorthodox inspection.

(We hope shortly to be reproducing an illustrated article on air reconnaissance of erosion problems *Hon. Ed.*)

FORMATION OF FUEL PLANTATIONS WITH *KUMRI* IN DRY AREAS

By J. M. Sweet, I.F.S.

(*Conservator of Forests, Bellary Circle, Madras*)

Summary.—We cannot afford to carry out intensive regeneration work in dry areas (except those that are very close to centres of demand) unless most of the work is done for us free of cost by "kumridars."

"Kumridars" will not be forthcoming unless they can be sure of at least two years unrestricted cultivation before we put in our forest crop. In very dry localities they should be given three years.

If this policy is adopted, not only will the cultivator be benefitted, and through him the country as a whole, but we shall stand a much better chance of raising successful fuel forests than we do at present.

There is an important aspect of *kumri* regeneration which has not hitherto received the consideration it deserves—at any rate in this circle. That is, the correct time to put in the forest crop in moist and dry areas respectively. The system of *kumri* plantations was evolved in moist areas, but in extending it to dry areas there has been little or no change in technique.

In teak *kumris*, for instance, after saleable timber has been removed an adequate quantity of inflammable material can still be expected, from the clear-felling of the remaining growth, to give a statisfactory and fairly even burn all over the area. The practice is then to plant up the area with teak shortly after the burning is completed and before the *kumri* crop is sown. The principal reason for this is to give the teak a good start over the weeds. In areas of moderate to heavy rainfall weed growth is usually profuse, but is held in check for the first few weeks by the burn. If planting were to be deferred to the second year, the teak would have to compete with a formidable growth of weeds and would also derive less benefit from the ash resulting from the burn. This applies equally to the field crop.

In dry areas, and I mean *really* dry areas with a rainfall of 20 inches or less, conditions are very different. There is seldom enough slash left to give any sort of a complete burn even on the strip 3 to 4 ft. wide and about 20 ft. apart on which seeds of fuel species are to be sown. This means that the *kumridar* has to sow his crop on a poor soil which has received very little benefit from a burn or from anything else. He probably has to spend much time on clearing the area of roots and boulders before he can plough, knowing that the prospects of recovering expenses in one year are remote. As regards the tree crops—*rab* experience has shown us how often highly susceessful original growth of seedlings on burnt strips dwindles and dies away after three or four years, when the beneficial results of the burn have been exhausted, unless the whole area is really fertile.

In moist areas the *kumridar* expects his best crop in the first year, which is when we plant our teak; but in dry areas any *ryot* will tell you that he does not expect to get a paying crop off newly-cleared land until the second or third year. If this is true, and it certainly is, surely what applies to agricultural crops must apply to forest crops also.

In the course of the last year I have seen a good deal of attempted *kumri* regeneration in very dry areas and the story everywhere has been much the same. In the first place it has been hard to find *kumridars*. When they have come forward, either willingly or by "persuasion," they have nearly always given up after a year or two, being unable to afford to carry on. The reason is obvious. The land they are given may be potentially promising, but it needs a lot of cultivation to bring it to anything like good condition. The *kumridar* is rarely a capitalist, but he has to bear the cost of clearing away roots and boulders and of ploughing; at any rate he has to devote to it his own and his family's time and labour which might more profitably be employed elsewhere.

Kumri is a word used in parts of Madras to denote the growing of forest and agriculture crops together (commonly known as *taungya*).

Kumridar—The cultivator who does the *kumri*.

Rab—Raising regeneration on small burned patches in an area.—*Ed.*

Fig. 5

A desert village. The fence surrounding the huts is of **Capparis aphylla** and the huts themselves are made of **Leptadenia spartium** and **Crotalaria burhia.**

Photo : Author.

Fig. 6

A village where the desert, cultivation and the Rann of Cutch all join near Rahim Bazar. Note how clearly the individual huts and the thorn hedges surrounding the groups of huts stand out.

Photo : Author.

Fig. 7

Salt deposits some 7 miles into the desert from the Rann of Cutch. These salt and sand flats are "sore spots" for wind erosion. Two patches of cultivation are seen in the foreground and hence the salt must be very local. The tree growth is **Prosopis spicigera** and **Acacia senegal**.

Photo : Author.

Fig. 8

The southern and western edge of the desert where the trickle of the Nara river loses itself in the Rann of Cutch. There is practically no water at all to be seen in the photo. The landscape is chiefly a waste of drifting sand with salt patches. There is however fair vegetation near the Nara.

Photo : Author.

In the first year he will be lucky if he gets a crop which will do more than cover the expense of ploughing, sowing and reaping. Often its value will be much less. He will be made to tend lines of tree seedlings and the degree of sympathetic treatment he receives from forest subordinates will largely depend on the success of the seedling growth. In the second year his ploughing will be hampered by the lines of the tree seedlings. Though seedlings may be much too close together, subordinates will threaten him with dire penalties should he or his bullocks damage one of them. Theoretically, the *kumridar* should be allowed to continue cultivation until the height of the seedling growth interferes with it. But in practice he frequently throws his hand in during the second year and we are left with an area which has been deprived of every vestige of cover except for the lines of tree seedlings, which generally are very slow in growth and too frequently fail to develop into trees.

The answer, as I see it, is to give the *kumridar* free and unrestricted use of the land for two or preferably three years. From conversations, I have had with the *ryots* in localities where now it is very difficult to get *kumridars*, I have little doubt that on these terms we shall get as many men as we want. In fact, when the news gets round we may even find them offering to pay for the privilege!

The *kumridar* will take over what is generally a hard and stony tract in no condition to absorb more than a fraction of the small rainfall it receives; but after two or three years of ploughing and cultivation it will be in a far more fertile and receptive state, and the prospects of getting good results will be very much brighter for agricultural and forest crops alike.

An examination of any cultivated field adjoining reserved forest will bear this out.

The average *ryot* is neither a knave nor a fool, and when he tells me, as several have done that not only will he benefit by being allowed three years of unhampered cultivation but that we also shall be the gainers when we introduce our tree species, I am ready to believe him. I would go further. When we are sure we have found the right man, I would be prepared to advance him money, on the security of future crops, to enable him to employ labour to remove roots and boulders, and generally to get the land into good heart as quickly as possible. After the forest crop is in he should be allowed to continue cultivation if it pays him to do so, for another two or three years, but he will be bound to sow selected grass seed along with the last crop.

A good opportunity for a demonstration of this idea has been missed in one division where in furtherance of the 'Grow More Food' campaign, some hundreds of acres of forest land were given to *kumridars* in 1943-44. The land was outside any fuel working circle and contained poor scrub jungle, though much of the soil was as good as any in those parts. The primary object of the scheme was to grow more food and there was no pressing need for growing more fuel; but the *kumridar* was encumbered with the responsibility for tending a forest crop from the very beginning. Even before he was able to clear his land 'spot sowings' were carried out departmentally, so that when he did come to clear it he had these irritating 'spots' to look out for. Those who were enterprising enough to get some of the land cleared for cultivation in 1944, were promptly burdened with lines of tree species, and many of them have given up the second year's cultivation because these lines gave them too much trouble. The whole area now presents the rather desolate scene of small bits of mediocre cultivation dotted about in a tract of partially cleared land much of which is now reverting to coppice and weeds. The additional quantity of food that has been grown is negligible and healthy established tree seedlings are exceedingly few.

The district staff cannot altogether be blamed, except perhaps for a lack of imagination, because it has long been our policy always to get our tree crops established on a cleared area at the earliest opportunity. In future district forest officers should be allowed more latitude and discretion in arranging terms with *kumridars*.

The present district forest officer and myself called a conference of the *kumridars* involved in this "Grow More Food" scheme and they unanimously agreed to return to the area and bring it all under cultivation if we would leave them alone for a year or two before introducing the forest crop.

UTILISATION OF DEGRADED RAKHS*

BY A. A. KHAN, B.SC., A.I.F.C., P.F.S.

(*Divisional Forest Officer, Attock*)

Introduction

The object of this paper is to discuss briefly the existing condition, potential usefulness, and policy and programme of work to be followed to get the maximum sustained benefit out of the degraded *rakhs* in the Punjab. The word *rakh* as used here implies waste land owned by government and managed as forest or grazing ground by the revenue department. Reserved and protected forests which are under the management of the forest department do not come under discussion here, though the technique for improving these is the same.

For the last twelve years, the forest department in the Punjab has been advocating a policy of soil conservation in lands owned by private individuals. Results achieved in this direction have been very encouraging. Taking only the item of control of waste lands, the department has succeeded in closing and bringing under scientific management 512,450 acres of waste land which were terribly denuded and eroded and extremely unproductive. This progressive policy which has yielded immense economic and social benefit to the rural population has unfortunately not been enforced in civil *rakhs* which cover a vast area of potentially productive land.

Area and distribution of civil rakhs

The total area of civil *rakhs* in the Punjab is 2,718,653 acres and their distribution according to civil divisions is as under :

Division	Cultivated	Uncultivated but culturable	Leased out for grazing or other purposes	Available for any other purposes	Total
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Ambala	12,610	3,268	8,524	10,794	35,196
Jullundur	262	2,187	1,069	..	3,518
Lahore	9,281	8,070	4,284	2,351	23,986
Rawalpindi	65,390	11,773	858,918	72,708	1,008,789
Multan	88,155	728,814	544,537	285,607	1,647,113
Total ..	175,698	754,112	1,417,332	371,460	2,718,602

Broadly speaking the eastern districts of the Punjab have far less civil *rakh* than the western districts because in the former case government gave excess waste to adjoining village communities. The reason for this difference in policy was due to the fact that the eastern districts were settled before the advantages of keeping part of the soil of a country in its natural state were fully understood. In the western districts settlement came at a time when government had realized the alarming dangers of reduction in the fuel and fodder reserves. It was therefore decided that at the time of demarcation of village boundaries the excess waste over and above the requirements of villagers should be formed into government *rakhs.*

Configuration of ground

Areas demarcated as civil *rakhs* can be grouped under two main heads as below :—

(1) Flat areas and gentle slopes which are fit for cultivation either under dry farming principles or as irrigated land with the extension of irrigation projects.

* Paper presented at the Soil Conservation Circle Officers Conference, Punjab, held at Hoshiarpur on 19th to 21st November, 1945.

(2) Broken up and ravined land which is unfit for cultivation but can profitably be developed as fuel and fodder reserves for the use of neighbouring villagers.

Legal position

All the civil *rakhs* are unclassed forest and as such are governed by " Rules for the management of unclassed forests, under section 50 and 50-B of the Punjab Laws Act 1872 ". Whenever the question of transfer of these *rakhs* to the forest department has come up for discussion, anxiety has been expressed about the weakness of these rules, but as far as experience goes, there has been no difficulty in protection of the forest under these rules. Arrest of offenders, compensation of cases and prosecution work have all been going smoothly. Some people have advocated reservation as the first essential before anything else can be done in this matter. I am not against the creation of reserves but this procedure will necessitate employing a large staff for a very long time before reservation is completed. This will mean indefinite delay in enforcing proper management. A way out of the difficulty for those advocating a stronger legal position is the application of the Chos Act which, since 1943, extends to the whole province. Incidentally this policy has already received the consent of government in the case of *rakhs* in Attock district.

Rights and Concessions

Practically all the *rakhs* are free from recorded rights of users except rights of way and water. Here and there some people may have a few unimportant rights but these all can easily be settled under the Chos Act. The *rakhs* are inavariably subject to concessions enjoyed by the local population. There is no legal bar to the withdrawal of these concessions but it will be advisable to withdraw them gradually if the goodwill of the people is to be retained in the endeavour to improve the *rakhs.*

Existing condition of growing stock

The deplorable results of the mistaken policy followed in the eastern districts attracted the attention of government fairly soon (1877). Denudation and erosion in the waste freshly acquired by villagers in Hoshiarpur, Ambala, Gurdaspur and Kangra was frequently discussed by local officers because devastation was spreading from the waste areas to cultivation lower down in these and other districts lying below. Several measures were undertaken to control this including the passing of the Land Preservation (Chos) Act in 1900 and the creation of a soil conservation circle in the forest department in 1939 to handle the problem in a scientific manner.

Up to this time the civil *rakhs* have, however, not received the attention they deserve under the general conservancy programme. At the time of formation these *rakhs* were fairly well-wooded scrub forests covered with species like *phulai* (*Acacia modesta*), *sanatha* (*Dodonea viscosa*), olive (*Olea cuspidata*), *karir* (*Acacia leucophloca*), *wan* (*Salvadora oleoides*), *kikar* (*Acacia arabica*), and *dhak* (*Butea frondosa*) according to the soil and rainfall zone in which they were situated. Grazing incidence being light, the grass cover was good both in quantity and quality. Combination of bush cover and grass growth besides being of economic value to the neighbouring population was adequate to protect against erosion. This condition could have been maintained and possibly improved upon if the management of the area had been in the hands of technically trained staff. But alas, this was not so. The management of these reserves of small timber, fuel and fodder which were of such immense local importance, was entrusted to civil authorities for the reason that these *rakhs* were of " local importance ". (The very reason that these should have been managed by technically qualified men). The civil officers responsible for the management had neither the technical training nor the spare time to devote personal attention to this work. Practically no work of improvement was ever carried out. Excessive grazing and browsing for nearly all the year round went on, on payment of nominal fees. As a result the earlier dense growth of nutritious grasses has been replaced by bare rock and boulders and less valuable coarse grasses. Illicit fellings combined with the natural death of old and overmature trees which were never replaced by sowing or planting, have resulted in the severe denudation of the *rakhs.* Detailed inspection of the civil *rakhs* in two representative districts (Attock and Amritsar) has convinced the writer that these *rakhs* which were once a great asset to the neighbouring villagers are now proving a serious liability due to their having become the source

of destruction. Erosion and gullying which started in *rakhs* due to their maltreatment are spreading into villagers' fields. Loads of silt sand and boulders transported by floods are being spread on to fertile fields lower down.

It is thus obvious that the scene now is far different from what it was at the time of the formation of these *rakhs.* Let us see what is possible to change this alarming state of affairs and bring about improvement. It may be mentioned here that the suggestions and proposals that will follow are based on the experience of work in the three most important civil *rakhs* in Attock district which have recently been transferred to the forest department.

General policy with regard to the proper use of land under civil rakhs

Allocation of civil *rakhs* to various uses like extension of agriculture, formation of pastures, development of fuel and fodder reserves, etc., is to be governed by the basic principle of "the greatest sustained benefit". Requirements of the public combined with suitability of the area to the best use under which it can be maintained in permanent productivity will determine the extent of area to be earmarked for each purpose. Viewed from this angle the civil *rakh* area can be classified into the following three main groups:—

(1) Flat or gently sloping areas fit for development as irrigated cultivation with the extension of canal projects.

(2) Areas fit for *barani* (rainfed) cultivation.

(3) Areas either totally unfit for cultivation due to steepness of slope, rocky ravined nature of the surface, water-logging, etc., or better suited for purposes other than cultivation.

According to the area statement in *Appendix A*, the total area of civil *rakhs* in the Punjab works out to 2,718,653 acres. Out of this the maximum possible area that can become available for cultivation (both irrigated and *barani* under groups 1 and 2 above) comes to 929,810 acres. The balance 1,788,843 acres and possibly some out of the cultivation group will be available for uses such as grazing grounds, grasslands, small timber and fuel reserves, etc.

Detailed policy and programme for development of each class of land

After having broadly classified the civil *rakhs* into three groups, the detailed treatment of each class of land is dealt with below:

A. Irrigated cultivation

It is an undisputed fact that claims of cultivation are stronger than forest preservation under the principle that the utilization of land is for the greatest good of the community. This applies to those flat areas which have remained *banjar* (uncultivated) due to deficient rainfall but can be converted into valuable cultivation when irrigation water is made available. This being so it is agreed that all cultivated and culturable waste which can become commanded by an irrigation project should be given up as scrub *rakh* in favour of irrigation but within each irrigation colony or project a minimum of 10 per cent. of the area and 10 per cent. of the water supply should be dedicated to growing fuel plantations and shelter-belts. A perusal of the area statement will show that these areas occur mostly in Thal and Bar (Mianwali, Shahpur, Muzaffargarh, Multan, Jhang, Lyallpur and Montgomery). A part of the area has already become irrigated and the balance will shortly be getting its water supply with the completion of Bhakra dam and Thal projects.

We have to relinquish these areas for cultivation and make room for the agricultural department to develop scientific agriculture. This however does not mean that the job of the forest department has finished. The disforestation of these civil *rakhs* in favour of agriculture seriously affects the supply of firewood in the following two ways:—

(*i*) Scrub land which was supplying firewood to towns and neighbouring villages is finished and supply ceases.

(*ii*) Increased agricultural population comes in and new towns spring up for which there is no new supply.

This firewood shortage not only affects the general public but seriously upsets the agricultural economy. Villagers, of necessity, have to fall back on cowdung which goes to the hearth instead of the field,—its proper place. Fields become impoverished due to lack of farmyard manure and the valuable work of the agricultural department in the evolution of high-yielding varieties is nullified.

The remedy for all this vicious circle is simple. In all colonization schemes, the forest department should be made to play its full part. A sufficient area of the civil *rakh* and irrigation water should be set aside for the creation of irrigated plantations to meet the needs of small timber and fuel. If no suitable government *rakhs* are available, private land should be acquired for the purpose. The bitter experience of the present province-wide firewood famine should be a sufficient jerk to make us pull up.

Besides the creation of big government-owned irrigated plantations, the forest department should adopt the following programme in new colonization shemes:

(*i*) Set aside 20 to 50 acres of land in each village for the creation of village forest to supply the villagers' needs for small timber, fuel and fodder.

(*ii*) Encourage planting up of shelter-belts and wind-breaks to protect the crops from the effect of hot and cold winds in these semi-desert tracts.

(*iii*) Plant up belts of avenue trees along all canal banks, all roads, old and new, and railway lines.

The above programme can, with considerable advantage, be introduced in the old colonies as well.

B. Barani cultivation

Due to the configuration of the ground canal irrigation is practically an impossibility in the hilly *rakhs* of Attock, Rawalpindi, Jhelum, Shahpur and Mianwali. Consequently all the cultivated land (and culturable waste when brought under the plough) will depend on rainfall. The question of cultivation in *rakhs* has been a controversial subject in the past. Some believe that it is a mistaken policy to allow cultivation in *rakhs* because it makes protection of the uncultivated part difficult and the standard of cultivation is so poor that it encourages erosion and goes against the general policy of soil conservation. There is some force in these arguments, but, in spite of this, I am in favour of allowing cultivation in culturable parts. In my opinion the present system is defective and needs complete overhauling. The fundamental abuse of the system is the utter lack of security of tenure. The leases are usually for one year and this insecurity of tenure gives no encouragement to the lessees to bring about any permanent improvement. Instead of abolishing cultivation and going against the "Grow More Food" campaign, we should so change the system that instead of causing erosion it strengthens the soil conservation programme and opens up avenues for employment of manual labour. The following are some of the important principles in allowing cultivation under the proposed system.

(*i*) Cultivation should be permitted only under a soil conservation colony scheme.

(*ii*) Cultivation *rakhs* should be divided into holdings consisting of 75 acres of land (25 acres for gradual conversion into properly terraced and *watted* (bunded) cultivation, 25 acres for growing grass and 25 acres for growing trees for small timber and firewood). As far as practicable holdings will run up and down hill so that each man's work will benefit himself and one man's neglect will not ruin someone else down below. This, in most cases, will be possible in the low hill *rakhs* where a top steep area can be reserved for trees, the middle slopes closed as grass-land and easy slopes reclaimed as cultivation. The aim should be to develop each unit into a model soil conservation holding.

(*iii*) Leases should be given on tenancy conditions for the first 10 years with a definite promise of occupancy rights and ultimate proprietorship after payment of *malkana* if land management is carried out according to provisions of lease. This is the most important condition for the success of whole system. No permanent improvement in land can be brought about unless the cultivator has reasonable security of tenure and some provision is made to reward his labour by grant of occupancy and subsequent proprietary rights. Lack of security in tenure has been and is the root cause of all trouble in the efficient execution of soil conservation programme in cultivated lands.

(*iv*) Lessees will have to afforest the woodland with suitable forest species under the advice of the forest

Fig. I

Mirjal, a private venture inclosure and wild life protection, near Fatehjang. Below such dams the amount of underground seepage is sufficient to produce a bush growth of fodder grass and trees. The fodder yield from such rejuvenated stream beds is of enormous value where all good grass has already been exterminated by over-grazing.

Photo : R. M. Gorrie.

Fig. II

Chimni kas near Musa, previously under cultivation, now a waste of shifting sands.

Photo: R. M. Gorrie.

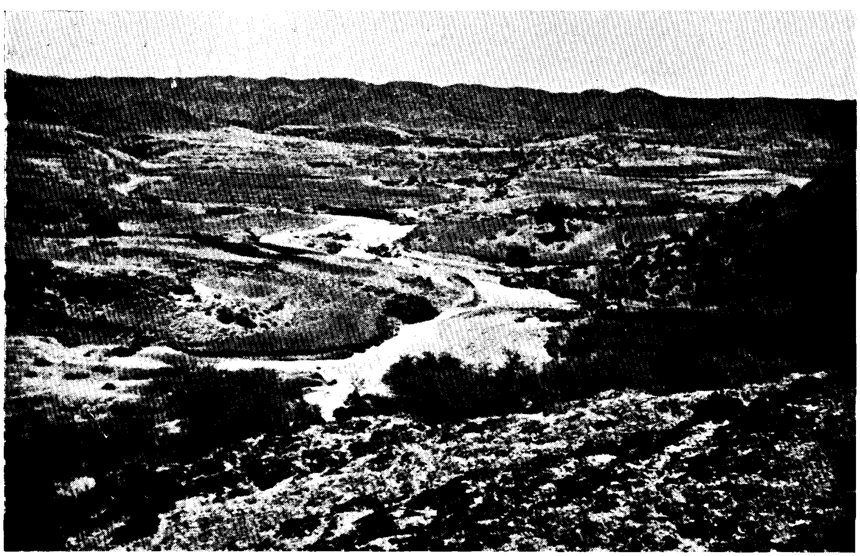
Fig. I

S:l torrent, near Pindigheb—background shows scope for reclamation.

This shows details of how brushwood spurs are built, with heavy posts sunk many feet in the sand. These spurs must be placed so that they are at a slight angle to the direction of the torrent. If placed at right angles across the stream they would be immediately destroyed.

Photo : R. M. Gorrie.

Fig. II



Gangarh—A study in uncontrolled runoff from the perfectly denuded Gangarh hill in the background, with sloping cultivation along its foot.

Photo : R. M. Gorrie.

department. Contour trenches may be essential to establish forest growth in the dry climate of the *rakhs*.

(*v*) Improvement of grass-land can best be carried out with the help of broad-based contour ridges and seeding of nutritious grasses like *anjan* (*Cenchrus ciliaris Linn*), *palwan* (*Dichanthium annulatum stapf*), *khar*. (*Chrysopogon montanus Trin*), etc.

(*vi*) Provision should be made for the fencing of the holding to make the closures effective. Fencing has given splendid results in Attock district and in partitioned *shamilats* of the Jhelum Salt Range.

(*vii*) In the grant of leases preference will be given to demobilized soldiers of the tenant class who had been cultivators before they joined the army. A very large number of men have joined the army from the submontane districts and it will help in their resettlement if leases are given to some of them. It is of course understood that no big landlords who act as middlemen will be given the leases and land will be entirely reserved for peasant farmers.

(*viii*) Detailed provisions will be made in the lease deed for observing up-to-date soil conservation methods advocated by the forest department. These may include ordinary terracing, *wattbandi*, construction of reclamation dams, spillways, and escapes, planting of live hedges and windbreaks, ploughing on the contour, growing of fruit trees where climatic conditions permit, etc., the number of the lessees' cattle will be strictly limited to the necessities of husbandry and domestic life (four bullocks, two milch animals and their calves, and a transport animal). No goats or surplus cattle will be maintained to produce animal products for the market, but the keeping of small numbers of properly-bred sheep should be encouraged.

It may be mentioned here that conditions have already been worked for a "model soil conservation holdings scheme" in Attock district. It yet remains to be seen what difficulties crop up in the practical working of the scheme.

(*ix*) A small sum by way of advance or cash deposit from the tenant should be taken at the time the land is leased. This will ensure that the tenant will put in the hard work which is so very essential if fields are to be made free from erosion.

It may again be said that the existing policy of cultivation in *rakhs* is undoubtedly defective. It is however hoped that a system of leasing of soil conservation holdings will be an improvement. The making of these soil conservation grants will give us, what we at present lack, land over which we will have more direct control than we can at present exercise by persuasion alone in the ordinary private holding. If properly controlled and developed it should be an invaluable demonstration and example of up-to-date soil conservation principles for the land-owners in the neighbourhood.

C. Area unfit for cultivation

Having discussed the maximum possible extension of cultivation and its scientific management we come to consider the proper use of the grazing area. The total area of the civil *rakhs* used for grazing is 1,788,843 acres. The following compares this area with the area of government forests and private closures under the management of the forest department.

	Acres.
Area of government forests (reserved, protected and other classes) ..	3,532,160
Area closed as a result of the activities of the soil conservation circle under I. F. A. Chos Act, etc. ..	512,450
Area of civil *rakhs* not available for cultivation ..	1,788,843

It will be seen that the area of civil *rakhs* which is being managed in an indifferent manner is nearly one half of the total forest area under the management of the forest department. We have been straining every nerve to persuade private owners voluntarily to close their private waste land. We have so far succeeded in

closing 512,450 acres of land (186,658 acres complete closure and 325,792 acres closed to browsers and fellings). Considering the indifference and even hostility of the peasantry towards the closure and the short time during which this work has been carried out the results achieved have been splendid (*Appendix B*). Results of voluntary closures under the soil conservation programme compare very favourably with closures in government forests.

	Complete closures.	Closures to browsers.
	Acres.	*Acres.*
Old Government forests ..	412,080	869,760
New voluntary soil conservation closures	228,766	300,061

Although the soil conservation closures of the last five years compare favourably with the total closures in the government forests, yet they are only 29 per cent of the total unculturable area of civil *rakhs* available for scientific treatment. This just shows what an immense amount of destruction and damage must be going on in these areas due to lack of proper management. It is therefore proposed that this extensive government land should be taken over by the forest department and managed under the general soil conservation principles which we are preaching for private areas but are sadly ignoring in government lands. I have on several occasions discussed the subject of transfer of management with civil authorities responsible for the management of *rakhs* and the general opinion is all in favour of management by the forest department. It is now up to the forest department to take the initiative. It may be mentioned here that I am not for the transfer of management overnight in the whole of the Punjab. We will have to take over gradually as and when we build up trained staff. Taking over the *rakhs* without proper staff will not be of much use and may even be harmful to our future propaganda and should not, therefore, be attempted.

There are several strong arguments in favour of bringing the civil *rakhs* under proper management. The *rakhs* are scattered all over the countryside and can serve the ideal purpose of fuel and fodder reserves for the groups of villages situated round them if properly developed and preserved. From the point of view of the needs of the rural population their situation is superior to that of valuable hill forests which are situated far away from centres of consumption in inaccessible localities. Properly managed *rakhs* will give watershed control in the soil conservation programme by preventing ravines and gullies where damage originates. Again these *rakhs* will serve as first class examples to demonstrate the value of closure, afforestation and other soil conservation works.

Policy

The policy of management should be to develop these areas in the interests of the local population. The demands of the villagers on these areas can be classified as under:—

(*i*) Grazing land,

(*ii*) Grass for stall feeding,

(*iii*) Small timber for agricultural and constructional purposes,

(*iv*) Firewood for domestic consumption to save cowdung as manure.

To meet these demands in a satisfactory manner the area will be divided into three groups.

(*a*) Scientifically-managed pastures to meet the grazing requirements in perpetuity.

(*b*) Properly developed grass lands to supply nutritious grass.

(*c*) Woodlands to supply small timber and firewood for domestic and agricultural purposes.

Technically speaking *rakhs* are generally free from rights and can be closed to grazing but it would be inexpedient to do so all at once. People have been used to grazing on concession and it will be of great advantage if closures are enforced gradually so that the goodwill of the public which is so very essential for this work is not lost to us.

A. Formation and management of pastures

FORMATION

To begin with large areas will remain open to grazing but decisions will have to be made fairly early as to the just requirement for grazing. No hard and fast rules can be laid down for the purpose because it will depend on several factors such as availability of cultivable and uncultivable *malkiat* waste in the village,

number of animals, other sources of pasturage (*e.g.*, reserved forests), etc. At the time of setting aside areas for pastures the following points should be remembered :—

1. The area should be close to habitation so that unnecessary inconvenience of driving cattle to and back from distant grazing land is minimized.
2. The area set aside for grazing should, as far as possible, be free from dangers of erosion.

Management

(*i*) *Rotational closures.*—Definite provision for rotational closure should be made in the management of grazing land set aside from civil *rakhs*. The area should be divided into two parts and each part should be alternately closed and opened. Rotational closure of pasture is absolutely essential if nutritious grasses are to be saved from extermination, but rotations can only be successful if the livestock is reduced to a reasonable number to start with.

(*ii*) *Watering arrangements.*—Adequate arrangements should be made for water supply for livestock. Existing water ponds should be improved by extending the wing walls to increase their capacity. New ponds should be constructed in bigger pastures and they should be scattered all over the area. If there is only one pond in the whole area this results in excessive grazing round about the pond and consequent erosion. Deeper ponds with lesser surface area are better than large shallow ponds from the point of view of reduction in evaporation losses. It has been estimated that six to seven feet depth of water is lost through evaporation from a free surface in the hot dry climate of our western districts. Planting of shade trees along the ponds will go a long way in reducing this loss and the consequent dry weather scarcity.

(*iii*) *Planting of shade trees.*—Trees of shade and fodder value should be planted 50 ft. apart with the help of thorny plant guards. These trees will provide shade to livestock for rest during mid-day, give leaf fodder during lean periods, and above all improve the quality and quantity of grasses in hot localities and particularly on southern aspects.

(*iv*) *Pruning of lower branches.*—Lower branches straggling along the ground should be pruned. Removal of these branches not only encourages good grass under light shade but in the case of thorny trees like *phulai* is greatly appreciated by livestock owners. This has already been tried with good results in a private paddock in Attock district. Observations have shown that the area occupied by straggling branches and producing no grass gave 1 to 2 lbs. per square yard. This increase in production works out to 59 to 118 mds. of grass per acre of uncovered area. Pruning of lower branches incidentally improves the form of trees and results in increased diameter growth.

(*v*) *Uniformity in the incidence of grazing.*—Placing of blocks of rock salt in less grazed parts helps in securing even incidence of grazing. It also improves the health of livestock.

B. Management of grasslands

Importance of good grasslands for cattle breeding industry

The north-western and south-eastern districts of the Punjab are as famous for the quality of their cattle as for the physique of their human population. Some quarters attribute the good quality of the cattle in these districts to the existence of extensive grazing grounds. This view is not entirely correct if one believes that the excellent specimens of livestock seen at cattle shows are brought up on pasture alone. The facts are that stall feeding in these districts is practised to a far greater extent than a casual observer can realize. A cattle-breeder in these parts attends to stall feeding from the very beginning of the calving. A calf is not only allowed to have the whole production of his mother but is invariably given an additional ration of milk from other animals. This additional ration is continued in the form of stall feeding of cut fodder, concentrates, etc., throughout life. Pastures actually serve only as an exercise ground because for the most of the year they do not carry much grass to eat. The climate of the Punjab, in general and of these cattle breeding districts in particular, is so inhospitable for pasture lands, that however well-managed these may be they can never give grass beyond the monsoon months. This being so, it brings us to the problem of producing grass for staff feeding for the remaining 9 months of the year if we want to maintain and improve our breeds and keep the cattle breeding industry prosperous. The obvious solution lies in the conversion of a part of our extensive but unproductive grazing grounds

into grasslands for the production of hay. Three of the degraded civil *rakhs* in Attock district taken over by the forest department are being gradually changed over from grazing to grasslands. It may be of interest to mention here that the surrounding villagers who, to begin with, did not like this change are now very happy with the arrangement because they can get enough grass from the closure safely to take them through the scarcity period.

WORKS OF IMPROVEMENT REQUIRED TO CONVERT DEGRADED RAKHS INTO PRODUCTIVE GRASSLANDS, AND BRING THEM BACK TO PRODUCTIVITY.

(*i*) *Closure.*—Closure to grazing is the first essential. Closure to grass cutting will be enforced for one to three years depending on the condition of the areas to encourage the natural seeding of grasses. In a well-grassed area grass cutting need never be disallowed but in an extremely poor area it may be prohibited for full three years.

(*ii*) *Artificial seeding.*—In an area completely devoid of or deficient in valuable grasses, artificial seeding will have to be carried out. Selection of species will be out of the best indigenous grasses. Exotics may be tried as an experiment but are not recommended as a general principle because these are easily ousted by local grasses. Out of the local grasses *anjan, dhaulu* (*Chrysopogon montanus* Trin.), *palwan, sariala* (*Heteropogon contortus* Linn.) and *sain* (*Elyonurus hirsutus* Monro) are suggested. Seed will be sown broadcast and the seed rate will vary from 12 to 15 seers per acre for complete stocking. Sowing will be done in loosened soil just before monsoon rains.

(*iii*) *Grass cutting.*—For the first few seasons after opening the area to grass cutting, cutting will be permitted from 1st October to 31st March. For another few years cutting may be allowed from 1st October to 30th June and later on permitted all the year round. The best time for grass cutting is when grass is in the milky stage and the villager should be persuaded and encouraged to cut the grass and make it into hay at this stage.

(*iv*) *Harrowing.*—Harrowing of grasslands is very beneficial to the grass and should be carried out where practicable. Harrowing should be done during the winter or early spring after a light shower of rain. On land with a pronounced slope, harrowing will be done along the contours.

(*v*) *Contour bunding.*—Contour bunding on easy slopes has proved very beneficial in conserving rainfall and preventing erosion and increasing the yield. Bunds will be of the broad-base type and their distance apart will vary from 50 to 150 feet depending on the slope, but intervening land should be given a closer pattern of small *kiara bandi* ridges to hold moisture all over the field.

(*vi*) *Contour trenching.*—On slightly steeper slopes contour trenches may be dug for the conservation of moisture. The effect of the conservation of water on grass growth is remarkable; the yield in many cases having increased two to three times round about the trenches. Trenches will however be limited to 20° slope because beyond this maintenance and repairs become expensive. In some of the degraded Attock rakhs yields of 250 to 450 mds. of *palwan* and *anjan* has been harvested from an acre of trenched land.

(*vii*) *Tree planting.*—The beneficial effect of trees on grass in hot dry localities has already been discussed under improvement of pasture. Conditions for soil and moisture conservation under and round the trees are better than in exposed places. In most of the degraded *rakhs,* open places carry inferior grasslike *khawi* (*Cymbopogon jawarancusa* Schult) and *chimbar* (*Eleusine flagellifera* Nees.) but underneath and around trees a luxuriant growth of superior grasses like *dhaula* and *palwan* is met with. It is a definite observation that in hot dry climates and

particularly along southern aspects, the high light shade of trees gives better grass growth both in quantity and quality than in exposed parts. The planting of trees of fodder and economic value will therefore be carried out along contour bunds and contour trenches. The ultimate spacing of trees will have to be not less than 50 feet apart.

(*viii*) *Pruning of lower branches.*—The value of the effect of pruning of lower branches on the grass growth has already been discussed under pasture management. It applies with equal force here. All the lower straggling branches of existing trees as well as freshly planted ones will be pruned to encourage better grass growth and take the maximum benefit from the area.

(*ix*) *Grazing.*—Grazing of cattle in *kharetars* (hay fields) after harvesting the hay is common practice in Kangra, Kulu and possibly other hills. Occasional light grazing by mixed herds of different animals is also advocated by the military grass farm experts in the interest of better upkeep of *barani* grasslands. The following advantages are given for light winter grazing in grassland after the grass has been harvested:

(*a*) The dead tops of the grass clumps are eaten down and this encourages new growth of leaf stem as well as tillering. The close grazing habit of cattle in dry areas will have a complete mowing effect.

(*b*) The treading effect of the animals has a mechanical cultivating effect on the soil and aids aeration of soil and the germination of seeds. This is particularly desirable for areas where harrowing is not possible.

(*c*) The droppings and urine of animals serve as valuable food material to the plants.

It may be pointed out here that the difference in rainfall and other conditions of the temperate hills of Kangra and the hotter and more arid western Punjab is vast and heavy grazing in the latter area will do damage. I would therefore say that grazing should be introduced only after a fairly satisfactory sward has been established. Even then very light grazing should be allowed once in a few years. Grazing will be allowed in winter and that too never after a rain because in that case soil is puddled and growing plants destroyed.

C. Woodlands

All those connected with the welfare of the villagers fully realise the importance of cheap, easy and near-at-hand supplies of firewood and small timber. The only way to check decline in the yield of agricultural crops is to divert cowdung from hearth to field. This is only possible if a cheap supply of firewood can be assured to take the place of cowdung which is the staple fuel of the farmer these days. The part the proper utilisation of civil *rakhs* can play to alleviate this difficulty has partly been indicated under pasture and grassland management where the growing of trees has been suggested. But these trees alone will not be sufficient to meet the requirements of the neighbouring population. Definite proposals are therefore being made to create woodlands for the use of villagers by afforesting suitable parts of the civil *rakhs*. Most of the civil *rakhs* are so degraded that very little suitable land is left for afforestation, only steep spurs and stony hillocks which it will be very difficult to afforest. In between the spurs and hillocks are however pockets and depressions which carry fairly good soil and are suitable for afforestation. These pockets and depressions when fully afforested with suitable species will become something like the *shola* forests of Nilgiri hills. Their value to the peasantry needs no comments. Only one example should suffice to show the importance of the work. Firewood in villages of the Chach tract in Attock district is selling at the rate of Rs. 3 to Rs. 3-8 per maund. The villagers have no alternative but to burn cowdung because they cannot afford to buy firewood at such a high rate to save cowdung for manure. And what is there next door? A civil *rakh* covering an area of 4,500 acres has been lying in an unproductive condition for years. What a difference it would make if you could supply firewood to these villagers at As 4 to As. 8 per maund and they could use cowdung as manure. The *rakh* has now been taken over by us and afforestation work has been started but it will

take a pretty long time before samething material is achieved. And incidentally this *rakh*, now literally treeless, is the same famous Attock *rakh* where Emperor Baber some 400 years ago killed rhinoceros and recorded the fact in his *Memoirs*. It must have been a very dense forest then.

Before closing I would put before you the technical problem which, as foresters, we have to solve. If we succeed in solving it in a satisfactory manner, and I am sure succeed we must, there is a ray of hope for the Punjab peasantry.

To put it briefly the problem is :—

How successfully to afforest these semi-desert rakhs and afforest quickly, cheaply and without many discouraging failures ?

For the last one-and-a-half years I have been working on the problem in the civil *rakhs* in Attock district. Some valuable experience has been gained but I shall not go into all the details here. I shall only briefly state the lines of action we have already followed and those we propose to follow.

The problems are :—

(*i*) *Impoverished soil.*—Due to misuse for generations, the soil of these civil *rakhs* is extremely impoverished. The soil over the greater part of the area is very shallow and stony and wherever a decent layer of soil is met with, it is very poor in nutrients due to constant surface washing. Organic matter and phosphorus are low though calcium is fairly satisfactory.

(*ii*) *Inadequate, erratic and shortlived monsoons.*—The total annual rainfall is round about 15 to 20 inches and two-thirds of it is received during the monsoon and one-third in the winter months. The monsoon rains arrive very late, *i.e.*, the end of July or the beginning of August and finish by the middle of September. Worst of all the rainfall is extremely erratic in all respects, *i.e.*, it may go as low as 12 inches, it may be as late as August, it may be as shortlived as a fortnight, and above all it may be in the nature of a few severe showers. With this sort of rainfall the problem is really difficult and we will have to use all possible measures to conserve every drop of water if plants are to be established successfully.

(*iii*) *Devastating autumn and summer drought.*—Drought is the greatest and most important of all the dangers to be encountered in this afforestation work. Months at a stretch may go without rain or cloud. The temperature goes alarmingly high and persists at that level for weeks. The maximum recorded during June 1945, went as high as 121°F under shade.

(*iv*) *Severe frost.*—Tender seedlings which escape the autumn drought are badly damaged by severe winter frosts during January and February. Campbellpur is perhaps one of the four coldest districts of the province. Last winter the minimum temperature went 5 degrees below freezing point (27°F) Frosty nights come at a stretch and are followed by clear sunny days which cause untold damage to frost-tender species.

Lines of work to combat the above mentioned factors

It is not intended to give details of silvicultural practice here but only a brief description of the special measures adopted to counteract the above mentioned dangers :

(*i*) *Proper choice of species.*—Special attention is paid to frost and drought hardiness of species. *Phulai* (*Acacia modesta*) *mesguite* (*Prosopis juliflora*), *ber* (*Zizyphus jujuba*), *kikar* (*Acacia arabica*) and *dhak* (*Butea frondosa*) have so far given satisfactory results. *Kikar* suffers badly from frost but gets established if it escapes damage for a couple of years. In certain low lying localities it may get completely wiped out in a year of heavy frost.

(*ii*) *Early sowings and pre-treatment of seed.*—The disadvantage of the brief rainy season is a corresponding reduction in the growing season available to young tender seedlings before they have to face autumn drought. To overcome this difficulty the earliest opportunity is taken to do sowings. For this purpose trenches are dug up during winter and this exposes the soil to winter weathering with beneficial results. Delay in germination of seed like *phulai* and *kikar* again cuts short the growing period by 10 to 15 days. To overcome this difficulty all seed is given either hot water or chemical treatment as the case may be.

(*iii*) *Sowing both at the bottom and on the berm of contour trenches.*—Experience has shown that in years of exceptional drought seedlings

Fig I

The principle of contouring is practised by the Punjabi in making his fields but has yet to be learned for his grasslands. Here is a demonstration of contour ridging planned to improve the fodder production in a civil unclassed forest in Attock district recently taken over for soil conservation work.

Photo : R. M. Gorrie

Fig. II

That Attock can produce fine cattle is proved here. The Sirdar of Kot's herd uses a paddock, half of which is always closed on rotation.

Photo : R. M. Gorrie.

Fig I

At Thoha in Pindigheb tahsil, one enterprising owner has reclaimed 120 acres of sandy waste and active ravines by building a series of earth bunds and using the torrent water to break down the ravine banks of clay to obtain a good mixture of clay and sand in his new fields.

Photo : R. M. Gorrie.

Fig. II

Current coupe in Kalachitta Reserved Forest alongside Basal road.

Photo : R. M. Gorrie.

inside the trench do much better than those on the berm, but the reverse is the case if a spell of continuous rainy days is experienced, as in that case seedlings inside the trench die but berm seedlings survive. On easy slopes contour bunding is combined with contour trenches to bring about the maximum conservation of water.

(*iv*) *Weeding, hoeing, and mulching.*—The value of weeding, hoeing and artificial mulching has long been recognised and practised in agriculture to conserve moisture. In forestry these long established practices have never been tried, beyond the nursery stage. Last year special controlled experiments were laid out in co-operation with the agricultural chemist on the moisture content of soil and survival of seedlings. Moisture figures have not been analysed yet but as judged from survival of seedlings, soil mulch (weeding and hoeing) has given better results than grass mulch (4 to 6 inches deep layer of grass) and control. Grass mulch did not do well because it was attacked by white ants and the latter after eating the grass attacked the seedlings also.

Judged from the co-operation in this experiment and the results achieved, I feel that there is great scope for co-operation between the agriculture and forest departments to work for the betterment of the peasantry. It may be mentioned here that further experiments extending over agricultural lands to study effect of terracing, *wattbandi*, wind-breaks, etc., on the moisture content of soil are being taken up jointly by the agricultural chemist and the author at Campbellpur.

(*v*) *The use of phosphatic manure to accelerate the root development of tender seedlings.*—It is a well known fact in agriculture that when rainfall is deficient or irrigation supplies scanty the application of phosphatic manures, by inducing root development, enables the plant to tap sub-surface reserves of water which would otherwise be beyond its reach. Phosphatic manures are also of great value in stiff soils where normal root development is likely to be restricted. It has been determined from the analysis of soil samples from all over the Punjab that the soils of Rawalpindi civil division as a whole are deficient in phosphorus. By putting these facts together I have come to the conclusion that the addition of artificial phosphatic manures may go a long way in solving our drought difficulties. Soil samples from our civil *rakhs* have been taken by the agricultural chemist and his analysis will shortly reveal the true facts about the phosphorus content of this soil. If his analysis reveals that civil *rakh* soil, like all other soils of Rawalpindi division, is poor in phosphorus, then a new experiment to compare the effect of different doses of phosphatic manures will be tried to compare

(*i*) *Effect on root growth:*

(*ii*) *Effect on survival percentage of seedlings after drought season.*

I may mention here that this line of development to get over the drought difficulty with the help of phosphatic manures is considered by soil experts to be full of promise. It is their opinion (and I entirely agree with them) that in the past foresters have attached very little importance to soil beyond its surface appearance. But wherever they have tried to solve the problem through soil study, results have invariably been promising. Three outstanding examples in this connection that I know of are :—

1. Laterisation of soil and teak regeneration in south India.
2. Podsolization of soil and fir regeneration in Himalayas.
3. Soil salinity, kankar formation and generation of *shisham*, *kikar*, etc.

APPENDIX A

Area statement of Civil *Rakhs* in the Punjab.

Serial No.	Name of district	No. of rakhs	Area in acres. Cultivated	Uncultivable but culturable	Leased out for grazing or other purpose	Available for any other purpose	Total
			Ambala Division.				
1.	Hissar	1	25		1,787		1,812
2.	Rohtak	3	1,024	34	2,372	89	3,519
3.	Gurgaon	2	666	321	465	..	1,452
4.	Karnal	16	10,872	851	3,899	628	16,250
5.	Ambala	..	..	..	..	..	..
6.	Simla	3	23	2,062	1	10,077	12,163
			Jullundur Division.				
7.	Hoshiarpur ..	1	..	1,813	..	..	1,813
8.	Kangra	..	..	..	..	..	..
9.	Jullundur	1	..	..	1,069	..	1,069
10.	Ludhiana	1	1	134	..	..	135
11.	Ferozepur	2	261	240	..	..	501
			Lahore Division.				
12.	Lahore	26	7,308	4,818	1,767	1,771	15,664
13.	Amritsar	3	32	1,319.62	..	2	1,353.62
14.	Gurdaspur ..	1	..	57	249	..	306
15.	Sialkot	16	513	1,872	..	301	3,686
16.	Gujranwala ..	9	428	3	2,268	328	3,027
17.	Sheikhupura ..	..	..	..	..	..	..
			Rawalpindi Division.				
18.	Gujrat	1	..	9.33	..	..	9.33
19.	Shapur	65	16,653	5,039	268,328	8,204	298,224
20.	Jhelum	22	1,816	1,892	5,401	18,395	27,504
21.	Rawalpindi ..	3	105	..	148	2,598	2,851
22.	Attock	35	2,496	2,216	41,563	41,455	87,730
23.	Mianwali	52	44,320	2,617	543,478	2,056	592,471
			Multan Division.				
24.	Montgomery ..	4	143	1,004	..	..	1,147
25.	Lyallpur	4	..	3,787	3,333	428	7,548
26.	Jhang	33	..	82,157	9,025	258,180	349,362
27.	Multan	90	4,237	306,262	16,733	13,852	378,984
28.	Muzaffargarh ..	58	3,193	257,082	461,490	..	721,765
29.	D.G. Khan ..	113	42,682	78,522	53,956	13,147	188,307
	Total :— ..	565	175,698	754,112	1,417,332	317,511	2,718,653

APPENDIX B

Progress of closures up to 1943-44

Serial No.	Division.	Chos Act Section 4.		Chos Act Section 5.		Section 38 of Forest Act.		Private closures.	
		Closed during the year	Total up to date.	Closed during the year.	Total up to date.	Closed during the year.	Total up to date.	Closed during the year.	Total up to date.
	1	2	3	4	5	6	7	8	9
1.	Kulu.. ..	..	..	..	..	..	..	..	..
2.	Kangra ..	..	..	..	..	..	..	..	..
3.	Kangra Forest Societies ..		71,019			1,028	1,200		
4.	Beas ..	..	..	..	..	..	..	..	..
5.	Lower Bashahr ..	..	..	..	..	..	430	..	..
6.	Rawalpindi ..	..	..	..	..	393	393	147	920
7.	Jhelum ..	..	..	..	..	..	3,497	..	..
8.	Gujrat ..	..	..	..	..	..	3,502	..	4,071
9.	Amritsar ..	..	..	..	..	..	1,879	..	..
10.	Ambala ..	..	45,857	1,349	20,420	2,061	2,061	..	..
11.	Karnal ..	..	..	..	..	619	14,112	..	..
12.	Hoshiarpur ..	2,298	208,916	7,218	72,022	15,432	56,098	..	5,217
13.	Attock ..	..	..	..	..	..	836	..	..
	Total :— ..	2,298	325,792	8,567	92,442	19,533	84,008	147	10,208

ENTOMOLOGICAL NOTES*

By J. C. M. Gardner

(*Forest Entomologist, F. R. I., Dehra Dun*)

13. Poisonous Honey

Several years ago, I bought a quantity of honey from a party of hill people visiting Dehra Dun. A trial of this was followed by a splitting headache. After a week's interval a replication of the experiment had the same sequel. Since I am not subject to headaches as a rule, there was at least a strong suspicion of the honey being the cause; the matter was left at that and no further trials were made.

In *Biological Abstracts*, 1945, entry 17,594 there is a reference to poisonous honey occurring in N. Anatolia. Examination showed that toxic honey contained pollen grains from *Rhododendron ponticum* (which contains a toxic substance) while normal honey did not. Old honey was not poisonous.

This perhaps explains my experience in India: the honey may well have been derived from *Rhododendron* or some other poisonous plant. Perhaps forest officers can give more information.

Since writing the above, Rai Sahib R. L. Badhwar, Minor Forest Products Officer, has informed me that poisoning from honey collected by bees from flowers of poisonous plants has been reported in literature from very early times. Honey from *Rhododendron californicum* Hook. and *R. ponticum Linn.* has been regarded as poisonous in foreign countries. In India the inhabitants of the Himalayas consider as poisonous honey from the local species of *Rhododendron* and *Pieris ovalifolia* D. Don, all belonging to the family Ericaceœ, due to the fact that cases of poisoning have sometimes occurred through eating honey. The honey collected by bees at the flowering time of *R. arboreum* Sm., particularly, is regarded as poisonous. Further, a sub-acid jelly from the flowers of this plant is prepared by local people in some parts of the Himalayas; if eaten in excess it is stated to produce intoxication. All these plants contain a highly toxic substance, andromedotoxin, and have been responsible for many deaths among livestock all over the world, including India. Andromedotoxin is a nitrogen-free subtance and produces symptoms resembling those of aconite poisoning. It is more poisonous than aconitine, and headache and giddiness are some of the symptoms experienced in andromedotoxin poisoning. It is very likely that honey from all these ericaceous plants contains this poisonous principle, most probably through its contamination with pollen. In fact, Wehmer (*Die Pflanzenstoffe*, 1929—31) reports the presence of 0.05 to 0.1 per cent. of andromedotoxin in honey from *R. ponticum*. Besides species belonging to the family Ericaceae to which *Rhododendron* and *Pieris* belong, other plants have also been believed to contaminate honey with poisonous principles. Among these may be mentioned species of *Datura*, which grow wild all over India and contain highly poisonous alkaloids, and *Melianthus major* Linn., a South African plant which has been introduced in Kumaon and the Nilgiris and has been established at these places.

14. Fertilization of teak flowers

I can find no definite information as to how the teak flower is fertilized; perhaps someone can either provide the information ready to hand or make observations. Small bees or other insects are probably concerned and it would at least be interesting to know which they are. It is quite possible that the creation of large areas of pure teak might interfere with the habitat of the insects concerned and lead to poor seed formation. In practice however it is customary to collect seed from specially selected trees in natural forest.

15. D. D. T.

This contact insecticide has recently received a very great deal of publicity in the press. Researchers however state that at present far too little is known of its properties and that its use requires caution. The chemical has been known for about 70 years but its use as an insecticide is recent, the Germans apparently having been the first to use it against body lice in the recent war. D.D.T. is a white powder that can be used in solution in kerosene or mixed

* Continued from the *Indian Forester*, Vol. LXXI, No. 3 dated March 1945, page 88.

with neutral dusts for spraying. It appears to be a nerve poison deadly to cold blooded animals (fish are very susceptible) but not to warm blooded animals unless swallowed. A very small proportion of humans are allergic to atmosphere containing it and may develop hay fever or skin eruptions.

When sprayed on to walls, etc., it remains active for six months or more but some insects (beetles, cockroaches) are less susceptible than others (flies, mosquitoes). Its use outdoors is attended with great dangers since large scale spraying would kill not only insect pests but insect predators and parasites and pollinators as well. A most important use if for spraying the insides of houses in regions where malaria, dengue, yellow-fever and similar mosquito borne diseases exists. Although mosquitoes may enter a treated room they are unlikely to escape even though they may have fed on infected humans. The use of D.D.T. against mosquito larvae in water however does not seem to be more efficient than the usual oiling or paris green treatments.

TRANSLATION OF TECHNICAL FORESTRY TERMS IN INDIAN LANGUAGES *

BY K. P. SAGREIYA, I.F.S.

Several provinces and states now have forest schools in which instructions are imparted through the medium of the regional Indian languages. As probably written text books in these languages are practically non-existent, the teachers as well as the students are greatly handicapped. A similar difficulty is experienced by those who want to educate the public in forestry to make it better appreciate the forester's point of view, and to disseminate useful information concerning forests and their management. It is time that ways and means were devised to surmount these obstacles.

The immediate requirement is the compilation of a vocabulary of all scientific terms used in forestry, including those of allied sciences, and the corresponding equivalents in the principal Indian languages, somewhat on the terms of the *Vocabulaire Forestiere* (German-English-French) with which forest officers are so familiar.

Leaving aside the local dialects, including those of the aboriginals, the principal Indian languages, *i.e.*, those with definite scripts, literature and style of their own, may broadly be classified from the philological point of view into three distinct categories, *viz.*—

(1) Dravidian, *i.e.*, Tamil, Telgu and Malayalam.

(2) Aryan, *i.e.*, Hindi, Bengali, Gujerati, Marathi, Ooriya.

and (3) Perso-Arabic, *i.e.*, Urdu, Sindhi and Punjabi.

The modern tendency amongst the first two is to derive new words from Sanskrit, whereas Urdu is enriching its scientific vocabulary by coining words from Persian-Arabic. Naturally the two sets of words *viz.*, those derived from Sanskrit, and those derived from Persian-Arabic, are quite distinct and the day is far distant—if it will ever dawn—when the people of India are likely to agree to adopt one single word, be it derived from Sanskrit or Persian-Arabic, as the standard Indian equivalent for English scientific terms.

It will thus be absolutely essential to coin two derivations, one derived from Sanskrit and the other derived from Persian-Arabic. For convenience the former may be termed Hindi and the latter Urdu. Words derived from Sanskrit should be given preference over popular Hindi equivalents which are understood over only the Hindi speaking tract, because the former can readily be understood by those whose mother tongues are Bengali, Ooriya, Gujerati, Marathi, Tamil, Telgu or Malayalam all of which use a large number of Sanskrit words. On the other hand, preference should be given to popular Urdu words as against those derived from Persian-Arabic because Urdu is taught all over India to those who claim it as their mother tongue.

The vocabulary should be divided into three parts. (1) English-Hindi-Urdu (2) Hindi-English-Urdu and (3) Urdu-English-Hindi,

* A somewhat similar article by Mr. Sagreiya appeared in these pages in the issue of October, 1940, on pages 592—600. Readers' attention is also invited to page 33 of the issue of January 1941 and to page 261 of May 1941.—*Ed.*

arranging the words in each part in the alphabetical order of letters in the first mentioned language.

After the English word should be given in brackets, in an abbreviated form, the particular subject to which the word pertains such as silviculture, entomology, botany, zoology, ecology, geology, physics, chemistry, mathematics, etc. After the Urdu and Hindi words printed respectively in the Urdu and Hindi scripts should be given in brackets their correct trans-literation in Roman script using suitable diacritical marks.

The preface to the vocabulary should indicate in brief the classification of the words into subjects, the symbols used for transcribing Urdu and Hindi words in Roman, and a general description of how the terms have been derived in these two languages from Sanskrit or Persian-Arabic by the use of various prefixes, suffixes, rules of syntax, etc.

This work can most conveniently be done by the Forest Research Institute, Dehra Dun, by passing a suitable resolution at the next All India Silvicultural Conference. The work of compilation could then be entrusted to persons best qualified to deal with a particular set of terms and these persons need not necessarily be all forest officers.

The opportunity should be availed of by the Silvicultural Conference, to compile a list of Indian names of plants and animals and Indian terms of forestry and allied sciences used in Indian literature and to give their corresponding English equivalents.

To summarise, in the interest of stimulating the interest of the public in forestry in general and to propagate the forester's point of view in particular, it is desirable that an English-Indian vocabulary of forestry terms be compiled and published by the Forest Research Institute at Dehra Dun as soon as possible. The next All India Silvicultural Conference should pass a suitable resolution to this effect.

KAKADU

By B. V. Patil.

(*Range Forest Officer, Shahapur*)

Kakadu has got for its male counterpart *Kakadya*. These names have come to be associated with the best-looking and most beautiful persons in the Dangs* and also in some other similar jungle tracts around the Dangs and away from the sophistication of modern civilization. The only deterioration of the standard that was once really high and which was set up by rigid conventions surrounding this name is sometimes now-a-days found where parents get a child after long craving. Their neighbours realise that the name *Kakadu* is given in such cases to their child to equalise the standard of beauty wanting in the child by mere name; and so they all condone it. In case some parents name an ugly child *Kakadu* they have to run the gauntlet of public critcisim and derision. To them nothing can be more misleading than naming an ugly child *Kakadu* or *Kakadya*. This encroachment is deeply resented by parents whose children have rightly come to be named *Kakadu* or *Kakadya;* for they do not like to swell their ranks nor to infringe the conventional standard of beauty indicated by this name. Especially *Kakadus* are much sought after by the prospective bridegrooms. The mere name is inviting; for behind that name there is a certain standard of beauty associated and come to be recognised. The bridegroom knows that he will have to be approved of by a *Kakadu*. So only after reassuring himself in these respects he will make an approach. Indeed *Kakadu* has come to be identified in these jungle tracts with a girl who has very fair reddish pink complexion, thin and cherry red lips, big grey eyes with big eye lashes, proportionate nose and slightly dimunitive figure. The boy *Kakadya* has the same complexion but he is tall and wiry.

As you casually walk through a hamlet in this tract you can flatter a girl or a boy and their parents by calling her or him *Kakadu* or *Kakadya*. They will all appreciate your sense of goodwill. They will, above all, be delighted to see a stranger who looks to things from their point of view. They will immediately become

*The Dangs is a forest tract to the east of Surat chiefly peopled by Bheels. The dialect spoken is a mixture of Gujerati and Marathi. The Bheels claim descent from former Rajput invaders and quite handsome types are met with amongst them

informal and as a result scramble for a *charpoy* or a bamboo mat to seat you.

It is not exactly known why this name has come to be chosen to betoken the best in this section of humanity. The *Kakad* tree (*Garuga pinnata*) which this name symbolises is a little attractive while in leaf with serrated leaves, deep red blaze and round yellow berries. But it has neither the attractiveness of a *palas* (*Butea frondosa*), *kahid* (*Albizzia procera*), or *bahava* (*Cassia fistula*), nor the utility of a *beo* (*Pterocarpus marsupium*), *ain* (*Terminalia tomentosa*), or teak.

Is it because of the alliteration in the component letters? I have not yet heard a word composed of hard consonants and still producing a smooth sound like *Kakad* and still less like *Kakadu*. Or is it because by naming a person after a tree the nearest approach to nature is made?; though that does not explain the selection of the *Kakad* tree. Nature in her pure form is always beautiful excelling everything that is made by man. Thus an humble approach to nature is made by naming a person after a tree.

So we find in the word *Kakadu* all that is beautiful judged from all standards. Kalidas, the renowned poet, has written poems to describe the standard of a beautiful woman whereas we have no word or words to describe the person symbolised by the word *Kakadu*. There is not a single name which is accepted as a common measure of beauty. We have gone away from nature. We cannot do better than adopt this name till we evolve a better one. For a Dangi *Kakadu* is the superlative of beauty.

PROGRESS REPORT OF THE FOREST AND ANTI-EROSION DEPARTMENT, JAMMU AND KASHMIR, FOR THE SAMVAT YEAR 2000

The total annual income, excluding the game branch, was Rs. 100,01,145 (Rs. 82,45,976, in the preceding year) and the expenditure Rs. 23,54,103, giving an expense ratio of approximately 24 per cent. The forest department contributed the highest revenue to the state during the year.

The total area under the control of the forest department was 10,788.76 sq. miles, and comprised in 16 territorial divisions.

The second revision of working plans prepared about 20 years ago was taken up and two plans were completed.

The survey of grasslands of two districts was completed and plans for rotational closures within 5 to 10 per cent. of the total area, fixing three years as the period of closure were under compilation. Eradication of the poisonous grass (*Oryzopsis aequiglumis*, Duthie) and cultural methods of various local and exotic grasses were studied in two localities.

Robinia and *Ailanthus* as also some exotic and indigenous conifers gave promise of success in the afforestation of Shankaracharya hill.

Cedrus deodara, Lond; *Pinus excelsa*, Wall. ex Lamb, and fir timber (of decreasing value in that order) was in large demand, but while there is abundance of advance growth of the two former, regeneration of fir is not satisfactory. The chief adverse factors are:—

(1) Insuffiicient seed production.

(2) Thick bed of undecomposed needles.

(3) Heavy grazing incidence.

In Pir Panjal, however, fir regeneration is coming up, especially in areas closed to grazing.

Due to a drop in the price of *Kuth* (*Saussurea lappa*, C.B. Clarke) there was a fall in the quantity extracted, and a welcome reduction in thefts.

The area under pyrethrum was *1310* acres. The total yield of pyrethrum flowers was 1358 maunds, which was sold for Rs. 1,32,899, the expenditure being Rs. 86,212 excluding cost of bags, giving a profit of Rs. 46,687.

J. P.

EXTRACTS

A PROPOSED SYSTEM OF SOIL IMPROVEMENT

BY MASON VAUGH.

(*Agricultural Engineer, Allahabad Agricultural Institute.*)

The term "soil fertility" may be used to designate these factors which give a certain soil the ability to grow crops of those plants desired by man. While the ability to store and retain water is not generally classed as an element in "fertility," the ability to store water is important in the growing of crops and may be affected by some of the factors which determine fertility.

The soil provides certain things: (1) Certain mineral substances or chemicals, many of them required in only minute amounts, (2) water (3) support—that is a place for the roots to grow and anchor the plant. In general, the root system which provides an ample absorption system will supply sufficient support. The mineral or chemical substances absorbed from the soil are absorbed as water solutions and are transported to the various parts of the plant in this form. Only soluble parts of the soil are available to the plant.

Soil may be considered as being composed of 3 parts:—(1) Mineral particles, finely broken up rock particles. The larger the particles, the "lighter" the soil; the smaller they are, the "heavier" the soil or the more clay-like it is. The texture of the soil is determined by the size of the mineral particles. (2) Organic matter in a more or less decomposed condition. In general, only that which is very finely broken up or decayed is considered a real part of the soil. It is called "humus" in this

form and in general carries the nitrogen present in the soil and available to the plants. The presence or absence of organic matter not only affects the supply of nitrogen but profoundly affects the "structure" of the soil and there by affects the ease with which it can be worked, the ease with which it absorbs water and other properties. (3) Fungi, bacteria and protozoa, the living organisms in the soil. Fungi and bacteria especially feed on the organic matter and convert it into humus, making available the nitrogen and other plant food in it. While some fungi and bacteria are harmful, causing disease, most of them are beneficial because without them organic matter would continue to accumulate in the soil as an inert mass, locking up the plant food they contain and keeping it unavailable to the growing plants.

In general, the, mineral particles are the source of the requirements of the plants for minerals. Small amounts are supplied by organic manure and it is possible to add the needed chemicals as fertilisers. Generally speaking, chemical fertilisers are relatively expensive and it is desirable to add them only when satisfactory crop yield are not secured without them. Many soils have sufficient amounts of mineral nutrients in them; in others the quantity present in available form may be too little to give crops of the most nutritious quality or too little to give crops of the maximum quantity the soil could otherwise give.

Mineral particles alone, even though they contained an ample supply of the mineral plant foods, would not be productive. Humus derived from organic matter decaying in the soil carries the nitrogen supply necessary for plant growth, to some extent for all plants and entirely for many or most crop plants. Without organic matter, a soil tends to have poor physical condition and so to be less easily workable. Humus supplies certain organic acids which help to dissolve the mineral constituents needed by the plants and so to make them available. It also helps to absorb and hold against leaching away the soluble parts of the soil. It supplies food for the soil organisms which serve many useful purposes in the soil, particularly the fixation of nitrogen from the air. A sterile soil is a dead soil, fertile at most for a very short time. Soils in which the mineral nutrients are sufficiently supplied through the use of chemical fertilisers but in which the supply of organic matter is not maintained soon lose physical condition and productivity.

Crops yields, therefore, may be limited by any one of the four factors, biological, chemical or mineral plant foods, water, or physical condition of the soil. Maximum yields of crops will only be secured when all four factors are present in optimum amounts. (Of course, it is recognised that the variety planted also affects the yield, that improved varieties may be necessary to take full advantage of the productive capacity of the most fertile soils. This paper deals only with soil productivity and assumes that the variety planted will be suitable.)

In the more humid parts of India, where the rainfall is 30 inches a year or more, crop yield is most commonly limited by the supply of organic matter in the soil, with the two associated factors of low nitrogen supply and poor water holding capacity. This can be observed in almost any village. The fields closest to the village site get most of the manure produced in the villages including night soil, partly because it is easier to get the manure to them and partly because their nearness to the village makes them easier to watch, therefore, the more valuable crops, which are more profitable to manure, are most often planted there. Crops grown in these fields often yield double that of those fields further away which do not get manure.

Experiments on government and private farms all over India, have shown that increasing the organic matter of soils practically always increases the yield, even of the better fields near the village site. This yield increase varies from a comparatively small amount on the most fertile lands to double, treble and even more on the poorer fields. Experiments indicate that increasing the organic matter of the soils of the Ganges alluvium can increase the average yield to at least double the present average. This can be arrived at without the purchase of commercial or chemical fertilisers.

If such a result is possible, what are the means of bringing it about? What are the steps necessary and how can they best be brought into Indian farming practice ? The rest of this paper will be devoted to discussing these questions.

There are three sources of organic matter for our soils, all at present inadequate or unused. They are (1) crop residues and weeds (2) farmyard manure, including compost; and (3) green manuring. Under the present system of cultivation and with the implements now in

use, the first and third kinds are practically unutilised and the second, farmyard manure and compost, are utilised much less than they should be.

There is considerable literature already available on the value of farmyard manure and compost and on how to prepare and use them. The fullest use should be made of such sources of organic manure. However, were all the barnyard manure and all the compost possible used, there would still be need for more than they can supply. I shall refer to only one thing in connection with these manures. At present, large amounts of cowdung is used for fuel. Compost has been suggested as a replacement for this material. Possibly investigation of the better utilisation as fuel of the weeds, leaves of trees, crop residues and trash which the villager is often urged to compost by the provision of suitable stoves for cooking would make possible the release of the cowdung for manure with less labour than is involved in composting. I consider the labour involved in preparing compost from village waste one of the great difficulties in its wide introduction in village practice. The manurial value of such compost made from village wastes needs to be compared with the value of such material as fuel in substitution for cowdung cakes. Possibly the difficulty involved in the introduction of better fire places for burning such material economically will be no more than that in introducing the widespread use of compost. Properly designed stoves would have the further advantage in addition to saving fuel for removing the smoke nuisance from the village kitchen, a desirable thing in itself. Such a stove would also use forest leaves, brush wood, etc., where available.

However, much we may increase to use of farmyard manure and compost, there is still need for better and fuller utilisation of field residues and green manuring, partly because of the insufficiency of the first and because the latter offers a source of nitrogen in addition to that supplied by the former. Field residues remaining after the harvest of the crops are largely or entirely lost because they are mostly blown away by the winds of summer from fields left unploughed till the start of the rains. Some stubble is picked up for fuel. Some is removed—and some grass and weed growth likewise—before the preparation of fields for subsequent planting, either because it interferes with seed bed preparation or because it is commonly believed that they develop certain poisonous or toxic substances in the soil. The true explanation, not commonly understood by the villagers, is that if they are left in the fields and worked into the soil, the bacteria in the soil use the available nitrogen in their life processes while breaking it down. With the very limited supply of nitrogen, the remaining amount is not sufficient to give vigorous crop growth. An increase in the available nitrogen in the soil would make possible the utilisation of this organic matter without the immediate depression of crop growth, resulting in increased fertility. I consider the removal of crop residues, stubble, etc., undesirable as a soil management practice, though in some cases it may be desirable for other reasons, as for instance, where their use as fuel releases more valuable dung manure.

Ploughing just after harvest gives time for the breaking down of this material before time for the next crop to be seeded. There are difficulties involved in this but careful planning will make it possible even with small steel ploughs and small oxen. There are two different problems in doing this, depending on whether the *kharif* or *rabi* harvest is considered. The common practice is to sow *arhar* in rainy season fodder crops, the *arhar* remaining on the fields after the other crop is harvested. Where it is desired to continue this practice, the *arhar* should be sown in lines 5 feet or more apart. If this is done, it is possible to plough with small ploughs between the lines without very much damage to the *arhar*. When a heavy crop of fodder is gotten, usually it will smother out the *arhar* so that as the fertility is increased by the use of manure, it becomes less and less possible to get *arhar* to grow in the fodder. Probably it will be more economical to grow the *arhar* separately and to have the fields clear after the fodder is harvested or if it is harvested for silage, to sow some other crop such as gram after the fodder. When the fodder crop is harvested, there is usually some moisture left in the soil. The sooner the ploughing can be done, the easier it is to do, as the moisture is lost fairly rapidly. Ploughing just after the harvest tends to kill weeds, stubbles of the fodder crop and other volunteer growth and so to conserve moisture for the *arhar*.

Ploughing after the *rabi* harvest involves even more careful planning of the work.

Usually up until the actual cutting of the grain and for a few days after, there is some moisture still in the soil and the soil is not too hard to plough with small ploughs. However, the remaining moisture is lost rapidly after the crop is cut and it is desirable to plough as soon as possible, within a day or two, after the crop is cut. The ideal is to do fields in the afternoon that are cut in the morning and to do the fields in the morning which were cut the previous afternoon. With steel ploughs kept in good condition, this is not difficult to arrange, once a person is convinced of the value of doing it. It is impossible with the wooden plough, except in very exceptional years when there is rain at harvest time or after. If the work is carefully organised, the ploughing can be done, in most cases, in the interval before the grain is dry enough to start threshing, when the oxen are used to trample out the grain. The introduction of the steel plough and planning of the work are the necessary steps in introducing this practice. Where the soil is reasonably soft at the time of harvest, the small steel turning or mouldboard ploughs can be used. When the soil is too hard for them, it may be desirable to use "rooter" type plough bottoms. These can be secured as attachments for some small ploughs.

While the other methods are helpful and should be practised, probably the use of green manuring crops will be necessary to build up our soils to a high state of fertility and to maintain them there. A green manure crop is one that is planted for the express purpose of being ploughed into the soil as a manure. While any crop so treated will increase the organic matter, the legumes are more desirable than non-legumes because they increase the nitrogen supply as well as the organic matter. Part of the desirable effect of green manuring can be secured by the growing of a suitable legume crop as part of the regular crop rotation. The soil fertility will be increased most rapidly if every field has a legume green manuring crop every year. Where this is not possible, the next best thing is to have a green manuring crop one year and a suitable legume the following, or alternate, years. For soil building, it is necessary that the legume be suitable, that is not only have modules on the roots but that it actually store nitrogen than it removes from the soil. Some legume crops, soya beans for instance, are desirable as crops but not soil builders because they leave less nitrogen in the soil than was present when they were planted.

In order to introduce a programme of soil building including green manuring, certain conditions will have to be met. First, suitable implements and procedures for their use will have to be introduced. The minimum implement used for green manuring is a small steel plough. While green manuring can be done with small mould board ploughs, the larger the plough used the more satisfactory the work will be. However, while larger ploughs are desirable, a green manuring programme can be carried out with small ploughs. Second, the green manuring crop must not occupy the land at a time it is required for a crop which is to be harvested. The margin of production is so small that we cannot afford to lose the use of land even for one crop season, in order to do soil improvement on the village holding. Where only one crop each year is grown on a given field, as is commonly true in most parts of India, it is easily possible to get a green manuring crop in the *kharif* season on fields to be planted to *rabi* as will be explained later. In the case of fields planted to *kharif* crops, the growing of a green manuring crop following it is not so easy but suggestions will be made as to how this also may be possible, without changing the rotations now followed. Third, the work of planting and turning under the green manure crop must not interfere with work on harvested crops at the seasons of rush work. Under present conditions, there is no time to spare at the season when crops are being planted and the green manure crop will always be deferred if it must compete for time and attention with a crop yielding food, fodder or fibre. Fourth, it is desirable that the green manuring crop be one that is not particularly good for human food or animal feed, lest there be temptation to harvest it for immediate gain rather than to plough it in for further benefit through soil improvement. As pointed out before, some crops which are harvested also may benefit the soil but probably, not to the same extent as would a high quality green manuring crop turned into the soil.

It is quite easy to meet these conditions, assuming that small steel mouldboard ploughs are available, on land that is to be sown to *rabi* crops. By careful planning as explained above, it is possible to plough these fields at the end of the previous harvest. If they are roughly ploughed into even fairly large clods, well

before the beginning of the rainy season, *sann* can be sown by simple broad-casting of the seeds among the clods before the rains start. The seed is not injured by lying in the hot soil or exposed to the sun, birds do not seem to pick it up, nor do insects seem to destroy it. The melting of the clods provide enough soil cover to bury the seed quite deep enough for good germinations. Leaving the soil rough on the surface is actually an advantage as the space between the clods provides pockets to hold therein till it can be absorbed instead of running off and a rough surface absorbs more moisture or absorbs moisture more rapidly than does firm compact soil. In this way, the seeding of the green manure crop is completed before the beginning of the seeding of the *kharif* harvest crops, and does not interfere with other work at that time. Similarly, whether green manuring crops are grown or not, it is necessary to start ploughing the field reserved for *rabi* crops about the middle of August if they are to be in good condition for the *rabi* crop. If this is not done, the growth of grass and weeds becomes too heavy to be handled by small ploughs, too much moisture is lost, the available plant food is tied up in the weed growth which does not decay in time to release the plant food for the succeeding crop. Being undecomposed, they interfere with cultivation also. The time for starting the full preparation of the *rabi* seed bed is the time when the *sann* should be ploughed under for green manure. The two are one operation and the seed bed is prepared in the normal manner thereafter. In this way, the cost of the green manure crop is only that of the summer ploughing and the seed used. The ploughing of all land at the time of the previous harvest is not only practicable but good soil management practice as well.

Assuming the availability of the steel ploughs, this system meets all the conditions. The crop does not compete with a harvest crop either for the land or for the time of the farmer. The *sann*, while an excellent green manuring crop and of some considerable value when mature, is not mature enough at the time it should be ploughed in to be of value for fibre, it is not commonly used as a fodder or food crop (except occasionally for goats) and the value of the following crop is usually much greater than the value of the *sann* if left standing till mature. Thus it should be easy to introduce the practice of growing a green manuring crop on all land to carry of winter or *rabi* crop.

Growing either a green manuring crop or a harvested legume after the *kharif* crop is not so easy as is the growing of a green manuring crop during the *kharif* season preceding a *rabi* crop. It is practicable to grow most legumes as interplanted crops with maize, *juar* or *bajra* only when these crops are thinly spaced. *Arhar* will survive more smothering than some of the other legumes but even it is smothered when the fodder crop is very heavy. In most cases, where the soil is fertile enough to grow heavy crops of these *kharif* fodders, it will be more profitable to seed them so as to fully occupy the ground, growing the legumes wanted for harvest as separate crops rather than as admixtures. If we consider the agricultural year as beginning with the onset of the monsoon, any soil building crop or at least any green manuring crop grown in the same year as a *kharif* harvest crop must follow the harvested crop rather than precede it as in the case discussed before of *rabi* fields. If the *kharif* crop is allowed to mature seed as is commonly done, by the time it is harvested, the soil moisture is low and by ordinary methods of seed bed preparation more moisture is lost. In contrast to the green manuring crop grown during the rains, the preparation or the seedbed and seeding of the green manuring crop at this time has to be done somewhat in competition with the seeding and care of the *rabi* crops. There is no generally recognised green manuring crop now commonly grown in India which is suitable for these conditions. Certain things are under test at the Agricultural Institute in the attempt to find both a method of seeding and a suitable crop for growing a green manuring erop after a *kharif* crop on the residual moisture in *barani* land.

Certain changes in present farm practice, consistent with the above recommendations for *kharif* green manuring, would somewhat simplify these difficulties. Early ploughing makes possible early seeding and, therefore, early maturity of *kharif* crops. Sorghum has been successfully seeded directly into fields ploughed in the dry weather, without intermediate seed bed pareparation, immediately after the first rain, thereby getting growth started 2 to 3 weeks before crops seeded by common methods in fields wholly prepared after the

rains start. This practice is good crop insurance in itself. The use of maize or the selection of an earlier maturing variety of sorghum would make possible an earlier harvest. Putting most of the sorghum grown into the soil for cattle fodder when still green and immature would also clear the fields earlier, and increased yields due to soil improvement would compensate for the loss of the grain from comparatively low yielding *juar* and *bajra*.

The adoption of the above suggestions would narrow the problem to finding a suitable crop and developing the necessary farm practice to go with it. Gram is generally recognised as being beneficial to the soil, it is a desirable food grain, requires the minimum of preparation of the soil and of moisture for good growth. It can utilise the small amount of moisture sometimes available better than any other common crop. If the practices recommended in the previous paragraph are adopted, the remaining change necessary is the development of a suitable procedure and equipment for seeding the gram with the least difficulty. Sufficient experimentation has not yet been done to recommend with confidence any one method. The following may be suggested as suitable things to be tried: (1) the preparation of the seed bed by the use of some tool which would only scarify the surface, getting the effect of a light disk harrowing; (2) the possibility of using some sort of a blade harrow, possibly a modification of the Acme harrow might be explored. (The use of the disk harrow is not suggested as it has not proven suitable for use with small oxen and the recommendations in this paper are confined to things which can be done with small oxen as power); (3) the possibility of seeding the gram with grain drills equipped with disk or runner furrow openers, directly in the stubble of the summer crop without any further preparaion of the seed bed whatever may be tried. Disk or runner furrow openers are suggested rather than hoe type openers because of the necessity of cutting through the trash Alternately, disk coulters might be set ahead of the furrow openers. Most weeds present would be nearing maturity and the gram may be able to smother winter weeds if a suitable method of planting can be found. Other legumes the gram should be investigated in the hope of finding something still better, particularly one which would make a good growth on minimum moisture when planted later than the common season for planting gram or possibly the development of a variety of gram especially adopted to late planting, in late November or December.

Among other possibilities that needs more investigation is the possibility of finding a legume which would lie more or less dormant while the land was occupied by the *kharif* crop, but would grow and develop when the crop was removed, and which would be adopted to the short days of winter and to comparatively little moisture in the soil. Such a plant might be one which re-seeds itself with seed which lie dormant till the early winter season and then germinate. A plant which could be sufficiently torn up by the seed bed preparation to not offer objectionable competition with the crop but still remain alive and ready to grow when conditions are favourable might be useful. Kudzu has been suggested as such a possible crop. Winter vetch has been suggested as a legume to investigate. Investigations of these have not progressed to the point where anything definite can be said about them as yet. Investigation of a number of legumes is being continued at the Allahabad Agricultural Institute in the hope of finding something which will fit the conditions of growing with a minimum of moisture in the Ganges valley during the months of November to February, which will fix nitrogen from the air and which is otherwise suitable for green manuring. If such a legume can be found, methods of growing it will be investigated. Suggestions from readers will be welcomed as to legumes likely to be suitable.

Experience at Allahabad and elsewhere shows that increasing organic matter increases yields. Consistent following of this system of soil improvement will increase the yield of crops, without the use of commercial fertiliser or anything which has to be purchased and without interfering with the normal production of food grains during the soil building programme. It has been shown that the soils of the Ganges valley contain enough of the mineral elements to support *yields* far above those commonly secured if nitrogen is supplied and if the physical condition of the soil is improved by addition of organic matter.

The question of *quality* of crop is yet to be investigated. Recent investigations in America have shown that the nutritive quality of crops may vary widely, depending on the amount

of available lime and phosphate in the soil. Animals not only grow more rapidly and yield better and more animal products when fed on the crops from soils having adequate supplies of Phosphorus but the animals themselves will choose the grass or other crop from the soil having the right balance of nutrients, when given a choice. As yet, no tests have been made at Allahabad to determine, whether it is necessary to use commercial fertilisers to secure the best *quality* of crops or not. This is still to be investigated and is important.

The author of this paper is convinced that this system of building soil fertility is practicable for the ordinary farmer and that it can be introduced generally in the villages. It is certain, however, that in order to do so, it will be necessary to introduce a whole system, not simply to advocate "green manuring" or "improved ploughs" or some other single item. The whole system needs to be demonstrated and explained as a unit.

Comment, suggestions or criticisms of the system is invited with a view to making it more perfectly adopted to the needs of the Indian farmer. We will be glad to hear of the experience of other workers with this or similar systems of building up soil fertility. We are convinced that it is one of the ways in which the income of the farmer can be most rapidly increased with a minimum of change in the general system of farming.

The Allahabad Farmer, Vol. XIX, No. 4, July, 1945.

MANURES AND MANURING*

SUDHIR CHOWDHURY

CHAPTER VII

NIGHT SOIL

The term 'night soil' has long been applied to human excrement. Human excrement is rich in nitrogen and phosphoric acid. It has been used in manuring fields in China from ancient times. In India crude night soil is used as manure to a considerable extent in the neighbourhood of the smaller towns in the Bombay Presidency. In other parts of the world, however, this has been used with great reservation as a manure. This is due to handling difficulties and to its being a ready medium for the conveyance of the organisms which cause various types of human diseases.

Amount of Urine :

It was found by Lecanu in experiments with 16 persons of different ages and sexes that the excrement of urine per 24-hour ranged from 525 to 2,271 gms. In experiments conducted on himself Lehmann found in a 14-day test with a mixed diet, that the daily excretion of urine amounted to from 879 to 1,384 gms. and in the course of a 12-day vegetable diet, it fell to from 720 to 1,212 gms.

Based upon these and other data, it is probably safe to estimate the average daily excretion of urine, per capita at about 1,200 gms. (about 4·2 lbs.)

The solid matter in human urine has been based upon the work of several investigators to range from about 34·5 to 87·4 gms. per day, though it is said to vary with the different nationalities. This variation may, however, be due to temperature and other climatic conditions rather than to constitutional differences.

The following percentages given by Lehmann, represent the relative quantities of some of the more important constituents of human urine:

	Urea	Uric Acid	Extractive substances and salts
With a mixed diet ..	32·5	1·18	12·8
With an animal diet ..	53·2	1·48	7·3
With a vegetable diet ..	22·5	1·02	19·2
With a nitrogen free diet ..	15·4	0·74	17·1

It has been found that the percentage of nitrogen in the urine of children of 8 months old is about 0·15; in that of men 21 years old 1·02 and in that of men 46 years of age 1·57

* Continued from the *Indian Forester*, March, 1946.

to 1·84. Based upon an average of 1,200 gms. of urine per 24-hour per individual the average daily excretion of nitrogen in the urine would amount to 13·36 gms.

The quantity of non-combustible salts is least in the urine of children, followed in turn by the urine of women, aged people and men. The variations, however, in individual cases and within these groups are very great. The chief constituents of the ash of urine, named in order are chlorine, soda, potash, phosphoric acid, sulphuric acid, lime, magnesia and iron dioxide, slight amounts of insoluble matter making up the remainder.

Amount of Solid Excrement :

The average quantity of solid excrement per day, as found by Lawes and Gilbert, for boys under 16 years of age, was about 108 gms.; for men between 16 and 50 it was about 152 gms.; and for men over 50 years of age about 226 gms. The dry substance ranged from 27·4 to 42·3 per cent.; it was found to be the greatest in the case of old men.

Chemical Composition of Solid Excrement :

The amount of nitrogen present in the average daily solid excrement of boys was 2·34 gms.; of men 1·94 gms.; and of old men 0·321 gm. The quantities of ash were 3·69, 4·23 and 8·32 gms. respectively. In the ash the phosphoric acid has been found to range from about 31 to 43 per cent.; the potash from 6 to 21 per cent., lime from about 17 to 27 per cent. and magnesia from about 10·5 to 15·5 per cent.

Composition of Human Excreta :

Hall, however, gives the following analysis for human excreta:—

	Faeces		Urine	
	Per cent.	lbs. per annum	Per cent.	lbs. per annum
Water ..	77·2	..	96·3	..
Organic matter ..	19·8	..	2·5	..
Ash ..	3·0	..	1·3	..
Nitrogen ..	1·0	1·04	0·6	6·9
Phosphoric acid ..	1·1	1·3	0·17	3·2
Potash ..	0·25	0·3	0·2	3·4

Utilisation as a Manure :

Many attempts have been made to utilise the fertilising materials contained in human excreta; on the crowded lands of China it is applied fresh to the soil and is daily fetched by hand from the cities for that purpose, but this mode of dealing with night soil is very unhealthy and is only possible with an excessively low standard of living. In the towns of Flanders and the north of France it was the custom to collect the excreta in large tanks, and after fermentation to cart them out in a liquid form to the fields, though modern views on public health are rapidly getting rid of such practices.

Earth Closet System :

Almost the only method of getting human excreta back to the land cheaply and inoffensively is in houses of small communities where the earth closet system prevails. There the excreta are mixed with dry shifted earth, which, deodorises them quickly and completely; the mixture is removed daily to a heap under cover and in a very short time the faecal solids are so completely broken down by bacterial decay that the soil can be spread upon the land and used for growing crops.

Poudrette from Human Excrement :

One of the products sold under the name of 'poudrette' is prepared by the Liernur process which consists in adding to the excrement sufficient sulphuric acid to fix the ammonia arising from the urea, sometimes with powdered turf, etc., to give the finished material a better mechanical texture, after which the mass is evaporated in a vacuum until it reaches such a consistency that it can be completely dried by other means and finally reduced to a powder.

The following analysis shows the composition of the resulting manure:

Water	..	13·9
Organic matter	..	63·7
Containing:		
Nitrogen	..	6·74
Phosphoric acid	..	3·12
Potash	..	2·16
Insoluble ash	..	3·45

Excrement Treated with Lime :

This method is said to have been first proposed by Payen and then by Muller and upon it is based the system of Mosselmann and Muller-Schur. By this process the ammonia which has been formed previously in the mass is lost. It is, therefore, important that the excrement be treated in as fresh a state as possible. Mosselmann used two parts by weight of burned lime to one of moist excrement and the final volume amounted to 2½ times that of the lime employed. In this process 100 parts by weight of lime volatilize about 25 parts of water and bind chemically and mechanically, about 50 parts more, thus producing a product which is so dry that it can be readily handled and transported and the heat generated is sufficient to destroy pathogenic organisms. The composition of the product formed has been found so in certain manufacturing villages in Rhode Island:

Calcium oxide	.. 11·28 per cent.
Potash	.. 0·09
Phosphoric acid	.. 0·91
Nitrogen	.. 0·43

One great objection to the material so prepared is that it is excessively rich in lime and if it were applied regularly in sufficient quantities, it would result in liming the soil to excess.

The A. B. C. Method :

In the absence of burned lime, alum, blood, and clay are added to the fresh excrement after which it is dried and ground. This process takes its name A.B.C. from the first letters of the names of each of the materials added to the excrement. The Method of Thon is based upon evaporation of the water by means of artificial heat. The product as prepared by Thon at Stuttgart had the following composition:

Nitrogen	.. 4·5 to 6 per cent.
Phosphoric acid	.. 10 to 12
Potash	.. 1·5 to 3

Method of Sundermann :

This method was adopted in connection with a hotel in Breslau, Germany. The excreta in this case were placed in a retort where they were not only dried but also subjected to dry distillation, in the course of which there were produced illuminating gas, carbon dioxide, tar and ammonia. The valuable products were saved; the gas after the removal of the carbon dioxide and subjugation to other purification, was used for illuminating purposes in the hotel. The resulting ash with a content of 5·57 per cent. of water was found to contain:

Lime	.. 6·5 per cent.
Magnesia	.. 3·0
Potash	.. 5·5
Phosphoric acid	.. 8·6

Sewage :

In cities and towns the almost universal prevalence of a water-borne system of dealing with excreta puts an end to all such systems and intensifies the difficulty of saving the fertilising constituents of human excreta for the land, because of the enormously increased dilution they have experienced. Every 1,000 parts of sewage is composed of 998 parts of water and only two parts of solid matter ; of the latter, half is organic matter and half inorganic or mineral matter. To utilise the fertilising value of the sewage, the latter is applied to the land in practically the same way that water is applied in ordinary irrigation. The use of sewage as a substitute for water in irrigation might be practised to advantage throughout all parts of the country which suffer periodically from scanty rainfall and it might often be practised as a temporary measure during droughts even in the humid regions. When the volume of sewage is large, compared with the area of land available, or when the land is heavy and not naturally well drained or easy of drainage, it may be necessary or advisable to submit the sewage to preliminary treatment for the removal or reduction of solid matters which would clog the surface of the land. Chemical treatment with sedimentation will remove a large part of the solid matter; plain sedimentation will remove less, and screening or straining still less. If the sewage is passed through a long, narrow and relatively shallow tank or tanks so that it will take twelve to twenty-four hours to make the journey 30 to 50 per cent. of the solid matter will be removed; some will be transformed into gases, some liquified and made more susceptible to oxidation, and some will remain in the tank as sediment or sludge. By this means less solid matter is passed to the sewage farm and most of what goes is more

easily converted into plant-food than when applied in its crude state.

Sludge :

The chemical composition of sewage sludge varies with the kinds of chemical used as precipitant. The following table gives a series of analysis of such sludges, made for the Royal Commission on Sewage Disposal in 1906, which may be taken as typical of this class of material:

	I	II	III	IV
Water ..	10·1	31·2	40·6	3·55
Organic matter, etc.	49·8	24·9	16·8	38·23
Nitrogen ..	2·32	0·94	0·55	1·65
Phosphoric acid ..	2·27	0·80	1·42	1·25
Lime ..	2·34	24·6	24·45	8·40
Potash ..	traces	traces	traces	traces
Insoluble matter	23·27	7·06	5·57	28·28

Of these sewage sludges I represents the material obtained by using as precipitating agents, lime, alum and sulphate of iron and then freeing the precipitated sludge of excess of moisture by passing through some form of pressure filter and then drying, II and III are lime sludges while for IV the precipitant had chiefly been sulphates of iron and alumina. It will be seen that *in no case is the material* possessed of much fertilising value. Field trials show that the action of these sludges as manures is very small. It seems desirable to conclude that these sludges possess little or no value as manures, though they may be valuable for the lime they contain, especially on light sandy land where they will also add some water-retaining humus and improve the texture of the soil.

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The Allahabad Farmer, Vol. XIX, No. 4, July, 1945.

DEATH TO WEEDS

One of the biggest pieces of gardening news in years: a spray that is poisonous to unwanted plants but not to animals or the soil.

By R. Milton Carleton.

A new horticultural chemical has been found which forces some of our worst weeds to commit suicide. The discovery—thanks to the scientists of the U. S. Department of Agricultural Research and others—is one of the biggest pieces of gardening news in years.

Toughest of all weeds to control are the deep-rooted perennials bindweed (also known as wild morning glory, and the No. 1 pest of the Midwest), Canada thistle, burdock dandelion. In the past the only way they could be destroyed was to root them out. But spray them with this new chemical, and the kill is sure. And it has made other amazing conquests.

Unlike old-time weed killers, the chemical is neither inflammable nor poisonous to animals. Unlike them, it does not corrode spray equipment, stain clothing or sterilize the soil.

The man who developed this pest-killer as a commercial product easily handled by home gardeners is Franklin D. Jones, of Ambler, Pa., one of the country's top authorities on plant hormones. He was hunting some effective means of destroying poison ivy, to which his children were unusually susceptible. He knew that plants absorb hormones and hormone-like chemicals through their leaves and carry them down to the root tips. Would a chemical too toxic to use as a hormone be absorbed by the plant and kill it? He chose nine of the hormone-like chemicals and sprayed poison ivy plants with them.

One of these, a relative of cyanide and deadly to animals, instead of killing the plants stimulated them into furious growth. Two others merely seared the leaves, and the plants recovered quickly. One by one they were eliminated until only two were left. Then Jones noticed that plants sprayed with them were beginning to turn brown. The drug had affected the metabolism of the plant. He

watched for these plants to come back, but they never did.

The chemicals found most effective were two complex organic acids which behave in much the same manner. The one commercially developed is trichlorophenoxyacetic acid, TCP for short. In tests with TCP at Cornell University, two of the country's leading plant physiologists and experimenters, Doctors Hamner and Tukey, got practically 100 per cent. kill on bindweed in ten days.

Because of its chemical structure, TCP is taken in by the leaves and carried through the branches down into the farthest root tip. The poison kills the foliage by destroying the chlorophyll. Just what happens inside the stems is not known, but apparently it either breaks down the cell walls or paralyzes them so that they can't function. Hamner and Tukey found TCP effective in doses as dilute as one part in 1,000 parts of water.

TCP has none of the drawbacks of old-time chemical weed killers. The latter caused plants to wilt in a dramatic manner. In two or three days the plants seemed dead. Shallow-rooted annuals were. But deep-rooted perennials regenerated from the crown and, unless enough chemical was used to poison the soil so that no plant could grow, most of the perennial weeds flourished all the better for the lack of annual weeds to compete with.

With TCP there is no sudden wilting. For four or five days the plants look as vigorous as ever. Then along the edge of the leaves a faint yellowish-green appears, which fades to yellow, to ashen gray, finally to brown.

The list of TCP's prey is long. Besides bindweed I have killed poison ivy, Japanese honeysuckle, ragweed, wild plum, wild cherry (including the chokecherry, host to the bagworm), blackberry, giant ragweed, plantain, dandelion, burdock, chickweed, Canada thistle, and sumac.

Other investigators have killed poison oak (particularly bad on the West Coast), bull thistle, yarrow, horse nettle, lambs-quarters, sassafras, honey locust, clever and wild garlic.

At a midwestern university, experimenters tried it on and old cotton-wood stump which had sent up suckers for a distance of 75 feet around. When treated, the sprouts around the stump wilted. Then outward from the stump the suckers began to collapse one by one, until slowly but inexorably the toxic material reached the last green sprout 75 feet away.

The best news for the conservationist is the high toxicity of TCP for Japanese honeysuckle, which has taken over large areas in the eastern United States. Orchardists have seen entire orchards overwhelmed in three to four years as a green wave of this pest, perhaps originating from a single plant, has flowed relentlessly across the landcape.

Jones discovered that most weeds are not easily affected when air temperatures are below 50 degrees, for then perennial weeds are living off their stored food and take up very little from the air and soil about them. Exceptions are poison oak, poison ivy, poison sumac, bindweed and Japanese honeysuckle; they may be sprayed at temperatures below 50 degrees, provided there is any foliage on the plant.

Jones, found, too, that perennial grasses are particularly hard to kill unless they are in lush, active growth. Hence under ideal conditions TCP can be used to kill weeds in your lawn during the summer when bluegrass is dormant (Bluegrass is vulnerable at certain stages of growth, notably in early spring and late summer.)

Distribution of TCP under the trade name Weedone was made to a number of experimentally minded gardeners last year. At first, a few adverse reports came in, but they were found to be from those who expected the familiar wilting of old-type weed killers. When given time to penetrate plant tissues, weedone has given practically universal satisfaction in destroying the susceptible weeds that have been listed above.

—*Reader's Digest*, July 1945.

STORY OF AUSTRALIAN WHEAT

By Frank Nunn.

"India hopes to receive during this month alone 50,000 tons of Australian wheat."—Report of statement by Sir J. P. Srivastava, Food Member, at a Press Conference in Lahore during January.

On the wheatgrowers of Australia has fallen much of the task of feeding a a hungry world. Large quantities of Australian wheat were supplied to India and to other countries last year. This is the story of the Australian wheat industry:—

When the first shiploads of British settlers arrived in Australia in 1788, there was only one practical farmer among them. But land was cleared and planted with seed where the city of Sydney now stands, and in December 1790, the settlers harvested with pride and satisfaction 300 bushels of wheat and 60 bushels of barley, as well as small quantities of flax, maize and oats.

Then it was found that the types of cereals introduced did not suit the climate, and that the soils of the coastal strip near Sydney, where the first crops were sown, were mostly unsuitable also. If the harvest did happen to be good, there was no export market at that time to which the excess could be shipped. When seasons were bad, stocks of grain ran perilously low, and belts had to be tightened.

These were fundamentals of production and economics. But the ingenuity of these new Australians was equal to the problems they faced. By 1812, farmers had moved inland, and north and south of Sydney, and were employing 4,500 men on nearly 10,000 acres of land, under wheat cultivation. In 1821 wheatlands covered 17,000 acres.

Land naturally was in plenty in the early days, and the heaviest demand for it came at first, not from the wheat farmers, but from men who wanted broad acres over which to run their sheep. These men, known as squatters, spread out over the rich back-country grazing lands of New South Wales. They held no title to the land their sheep grazed over. An attempt was made in 1831 to straighten out the land tangle by the introduction of regular land sales. By then, however, squatters and their flocks had drifted beyond the reach and the control of the authorities. So they were granted licences at £10 a year, giving them grazing rights over runs in unsettled areas. Later in 1847, they were given the first right to buy at £1 an acre, land on which they wanted to 'squat' permanently.

Unlock The Land

But land ownership became a more complicated question when gold miners, who poured into the country during the fifties, began to leave the diggings and turn their interest to farming. They found that the squatters had got rights to nearly all the best farming country. "Unlock the Land" became a popular cry; and in 1861, Land Acts were passed permitting selection of from 40 to 320 acres anywhere on Crown Lands. The selector had to pay one-quarter of the price of £2 an acre as deposit, and reside on the selection for three years. After that he could buy the land on easy terms.

These were stormy days in Australia's rural development, and there was much conflict between squatters and selectors. The squatter went right ahead and took out selection rights on picked land for his children, and put stand-ins in occupation for the three years. A selector would sometimes wait until the squatter had improved some land on which he was squatting, and then move in and charge the squatter with trespass.

The selectors were, for the most part, wheat farmers. The importance of the Land Acts lay in the fact that they took wheat production away from the coastal areas and established it on the inner plains.

It was not possible for the industry to develop fully until railways were built across the ranges which separate the seaboard from the plains right round from Sydney to Adelaide. And even after they got the railways, wheat farmers were still faced with difficulties in getting suitable seed.

New Varieties

So they set to work to breed their own varieties. Prominent in these experiments was an Englishman named William Farrer, who had been making tests at his homestead in New South Wales.

In 1890, Farrer was called to a government conference which was discussing the rust disease appearing in the crops. He went back to his experimental plots and produced a wheat which came to harvest at the right time, gave more bountiful crops, grew in areas where the rainfall previously had been considered too light, and possessed finer milling qualities.

William Farrer has gone down in Australian history as the man who put Australia's whole wheat industry on a new basis. His wheat still grows tall and green and ripens into a golden harvest on Australian plains. It is his living monument, and bears his name.

From three crores of bushels in 1890, the Australian wheat yield soared up to nine crores of bushels in 1910. In 1939-40, production was more than 21 crores of bushels. This was a record harvest. The average production is 162,000,000 bushels annually, valued at approximately Rs. 30½ crores. This yield, after providing for local needs, leaves about 11 crores of bushels over for export either as grain or flour (although of course the recent great drought in Australia imposed a serious setback on production).

The industry obtains assistance from agricultural research institutions which experiment with seeds, soils and fertilisers.

Mechanical Aids

The best wheat-growing areas, such as the Riverina district in New South Wales, and belts in South Australia and Western Australia, produce up to 30 bushels an acre. But there are lighter rainfall areas which are not so rich in high grade wheat, and they reduce the overall average to about 14 bushels an acre.

Difficulties of dealing with land won from virgin forest, imperfectly cleared, and with stumps of trees still ungrubbed, were overcome in the 1860's by the stump-jump plough, an Australian invention. The shares of this plough lift automatically when they strike roots or a stump. In 1843, a stripper was built. Forty years later came the harvester, which stripped the crops and winnowed at the same time. That reduced harvesting labour to a ride round the paddocks with an occasional stop to bag the clean grain in the box. The success of this harvester led, too, to the establishment of one of Australia's most important industrial plants, with a world trade in agricultural machinery.

PART II

Determination Wins

Wheat growing in Australia has been dealt some hard blows on occasions from droughts, such as that which parched the country last year, and collapsed markets.

One of the first setbacks the industry received was in 1851, when many farmers deserted their farms for the gold diggings. This setback was temporary; and was offset by the move away from gold prospecting to agriculture, when alluvial gold began to appear to be worked out.

The rushes had brought increased population, and so bigger demands for wheat, but the construction of railways gave the wheat farmer his most substantial aid; it provided cheaper haulage to the coast, and opened up new country.

The largest area under wheat crop in Australia was in 1930-31, when twenty-one million acres were sown. This area, however, shrank to twelve million acres in 1935-36, but rose to eighteen million acres in 1938-39. The wheat lands of Australia comprise a broken strip of country running southward from the border of Queensland, inside the New South Wales coastal ranges, and across the north-west of Victoria into South Australia, where they thin out tin the arid region of the coast of the Great Australian Bight. In Western Australia, the wheat belt avoids the coastal areas of poor soil on the one side, and is limited by the low rainfall zone of the interior on the other side. It thins out north of Geraldton, where the rainfall is unsuitable.

The largest wheat-producing State is New South Wales, with four-and-a-half million acres normally under crop. Victoria, South Australia and Western Australia generally have about two-and-a-half million acres sown. A few years ago farmers were inclined to extend wheat boundaries to the rim of the dry centre. This was defiance of and a challenge to Nature, and the farmer generally took a beating. Now

the technique is more intensive development of the regions of better rainfall nearer the coast.

It is a normal happening in any year for some districts in Australias' wide continent to have a bad season. The swing of the seasons is something Australian farmers and the men on the land generally accept as a condition of their gamble with the rainfall.

Makes Dream Come True

The Australian wheat-farmer, though, is a hard man to discourage. He will select a tract of virgin country and dream it into a fine farm with thousands of acres of crops and a comfortable house for his family. Then he will take his coat off and work to make his dream come true.

Australian wheat-farms vary in character according to their age and location. Some are small holdings which never yield more than a a living. Others are big and mellow with ripe curves where they embrace hills and valleys. All may have the benefit of advice from Government research officers who have conducted experiments in the same districts. These officers advise on disease control, use of fertilisers, crop rotation systems, and general soil control measures.

Nearly all farms, large and small, are mechanised by the use of tractors, multi-furrow disc ploughs, cultivators, combined seed drills and fertiliser distributors, strippers or harvesters. Some farmers who run their properties single-handed, or with the assistance of one or two paid workers, get contractors to put in seed and take off the crop.

The way mechanisation has affected the productivity of Australian wheat farms can be traced in the Official Commonwealth Statistics for agriculture. Machinery worth Rs. 43,00,00,000 was used in 1938-39, compared with Rs. 16,12,50,000 worth in 1913-14. The value of machinery per acre rose from Rs. 10-11-4 to Rs. 18, with the result that the number of acres worked per man rose from 70 to 136.

Australian farm machinery does not generally include vehicles for transport of the yield from the farm to the railway. A haulage contractor in most instances does that. Once he used to build up great stacks of bagged wheat at the sidings. Now it is handled in bulk. In the more prosperous areas, concrete silos are provided for storage at the rail sidings and depots; but in Western Australia they are mainly crudely constructed bins of stakes and burlap, open to the sky, but closed to rats by a barrier of tin with an overhang. The railways open bulk-wheat trucks are loaded by shovel or by elevator, and hauled to a port, where the wheat is stored in soils, or goes straight to the wharf. Special machinery loads the ships. Haulage contractors generally look after the farmer's fuel and superphosphate loadings as well.

Social Amenties

Without taking into account this type of worker, it is estimated that 26 per cent. of Australian wage-earners directly depend on primary production for employment. Wheat-growing absorbs normally about a quarter of this number. The way they live is as important to the industry as is the fertility of the soil, the bounty of the climate, and the technical knowledge, skill and industry of the farmers.

A recent Rural Reconstruction Commission survey stressed the necessity for keeping the man on the land contented. This is something in which the Royal Agricultural Society and the Country Women's Association in each State take a deep interest.

The social life of the farmer and his family centres mainly round the community hall, probably built by community effort, where dances, card tournaments, movie shows and church services are all held. With the addition of radio in his home, these features seem to satisfy most farmers in Australia.

State Governments provide schools at selected spots, accessible to the majority of the children, and not altogether inaccessible to most of the others. For those who are unable to overcome the difficulties of travelling long distances, lessons by correspondence are provided.

—*Australian Agricultural Newsletter* No. AGN/120.

ESTABLISHMENT OF FUEL PLANTATIONS

KHAN BAHADUR NIZAMUDDEEN HYDER

Ex-Director of Agriculture, H. E. H. the Nizam's Dominions, Kakori, Lucknow

The necessity of adequate supply of organic matter to agricultural land in India has always been recognized. The land is practically deprived of such a valuable ingredient of manure because of the prevalence in our villages of the wasteful practice of burning the cattle dung. The villager cannot give up this practice. He must have fuel for cooking his food. He cannot afford to use purchased fuel. Alternative fuels like coal, oil, etc. are, therefore, out of question. Wood is a fuel which can be produced locally, as against other articles which have to be imported into villages from outside involving heavy cost in transport. But, the villagers are not expected to agree to spend money on buying even the locally-produced wood. They can be expected to use *it provided they get it without paying any* price. In the following is given an outline of a scheme by which wood can be made available to the villages without much cost. It may not be practicable for all villages in India, but with suitable modifications it can be put into practice in many of them.

Fuel plantations in villages

Establishment of fuel plantations was recommended by Voelcker more than 50 years ago. Though it has generally been considered a useful recommendation, little has as yet been done to give effect to it. The *Memorandum on the Development of Agriculture and Animal Husbandry in India* issued by the Imperial Council of Agricultural Research also contains a recommendation that fuel plantations should be established in villages. While making other recommendations, it says: 'It is often urged that what is used as fuel should be utilized for manurial purposes and the fuel requirements met in other ways.' Further on, it says: 'For this purpose fuel plantations should be established as soon as practicable. Plans should be prepared for each village showing what area is available for each group of villages for such plantations, what quantity of wood can be produced from it every year (after the first 5 or 7 years) and how much fuel would be required by the people to meet their needs. It has been established that an average family needs at least 5 sr. a day or nearly 50 md. in a year. This would be available from half an acre of fuel plantation. Thus, each village would need about 60 acres under fuel trees.' In an earlier article entitled 'Financing Agricultural Development in India'[1] I had suggested that fuel plantations should be established as a necessity of the nation, by landowners, District Boards and Government, and that no revenue should be charged for this land, and the cultivators should, under proper control, be allowed to take the necessary amount of wood free of cost. While the villagers cannot be expected to use cattle dung for manurial purposes unless fuel is made available to them free of cost, it is at the same time difficult to induce the landlords to allow their lands to be utilized for fuel production unless they are *satisfied that they will also materially* benefit by doing so. The scheme presented now does not ask for much sacrifice from landlords or any other party, nor does it demand investment of large amounts of capital. It only asks for co-operation between the concerned parties for mutual benefit.

Co-operation in fuel plantation

The idea underlying this scheme, briefly expressed, is that the landlord and the villagers should establish and maintain a fuel plantation in co-operation, and both the parties should benefit by its produce. Assuming that a village has 100 families, it would need a plantation of 50 acres for supply of sufficient fuel for the whole year, at the rate of half an acre under fuel trees per family. Assuming also that the landlord himself needs four times as much fuel for his own use, *i.e.*, 20 sr. a day or say 200 md. for the year, an area of 2 acres will be required for production of fuel for him. The landlord should, therefore, make 52 acres of land available for the establishment of a fuel plantation. He should not charge the villagers any rent for it, and the Government should not ask him for any revenue. The landlord should provide seeds or seedlings of fuel trees at his cost. The villagers should prepare the land or dig the pits and sow the seeds or plant the seedlings supplied by the landlord. Any of the villagers' families which cannot itself do this work, should provide labourers at its cost or

[1] *Indian Farming*, Vol, III, No. 2 February, 1942.

should pay for the labour which will have to be engaged for doing the work on its behalf. Subsequent filling of gaps in the plantation should also be done on the same basis of co-operation. No wood should be taken from the trees until they have attained the optimum size. When cutting of wood is to be commenced, an estimate should be made of the actual requirements of fuel of each family. Cutting should be done under supervision, on dates previously settled and notified. Each family of the villagers should cut the permissible amount of wood and take it away free of cost. While each family cuts wood for its own use (say 50 md.) it should cut 2 md. of wood for the landlord. The landlord will, in this way get 200 md. of cut wood for his use, at the rate of 2 md. per family of the villagers. He can use this wood himself or sell it. No other person in the village should be permitted to sell the wood which he gets free of cost, from the plantation. The landlord can derive still more benefit from the plantation in another way. When the trees have become strong enough he can start goat breeding and sell milk and animals for meat or sheep breeding and sell wool and animals for meat. The animals will graze in the plantation, and they and their progeny will bring so much income to him that in the long run he may find that such a plantation is as pofitable as the land which is used for growing of crops. No family which does not co-operate in the establishment and maintenance of the plantation shall be entitled to get wood from there without paying for it. It must obtain it on payment of price at market rate. From the date wood is made available to the villagers from the plantation, no dung from the cattle in the village should be allowed to be burnt. All of it should be used for manuring the crops. No family which does not put all the dung from its cattle into its fields, should be granted wood from the plantation free of cost, even though it may have co-operated in the establishment and maintenance of the plantation. Management, supervision and control of the plantation and of all operations in it should be the responsibility of the landlord or of a committee of the villagers of which he will be the president.

Conclusion

It will, however, be seen that the success of this scheme depends on willing co-operation between the landlord and the villagers on the one hand and between the villagers themselves on the other. There may be places where such willing co-operation is not forthcoming. For such places, it is suggested that the Government might acquire waste land and make it over to a co-operative society, on certain conditions, with powers to enforce the plan which may be prepared for planting trees, cutting the wood and carrying out other operations, in the fuel plantations.

—*Indian Farming*, Vol. VI, No. 10, October, 1945

ON PROFESSIONAL LANGUAGE

By E. G. Cheyney

Professor of forestry, Division of Forestry, University of Minnesota, St. Paul, Minn

The author urges foresters to stick to well-established terms with definite meanings and to avoid the use of such an unstandardized term as "selective logging", which means all things to all men.

Forestry is a young profession in America, but it did not originate here. It can point to quite a long and respectable history in Europe. In fact, in comparison with some of the other professions, it might be considered fairly old and well established.

In the course of its development in Europe there has been created a rather adequate collection of technical and professional terms to designate certain forestry operations. These terms are well established and generally understood wherever forestry is practiced. They greatly aid in the description of technical operations, many of which it would be hard to explain without their use.

Then, why should not these terms be used in the United States?

The writer does not consider himself a purist. He would regret to see the foresters resort completely to a foreign language, as the ecologists and doctors do, because he feels that the foresters have nothing to hide and want their writings understood by the man of average education.

But there would seem to be very little excuse for avoiding already establish terms.

A very large number of the foresters in this country have been brought up on Hawley's *Silviculture* and are perfectly familiar with such terms as "clearcutting," "seed-tree method," "shelterwood," "coppice," "selection system," "thinning," "improvement cutting," "release cutting," etc. By means of those terms, and recognized variations of them, any operation in the forest can be adequately and intelligently described. There would seem to be no excuse whatsoever for resorting to new, vague, and unintelligible terms.

And yet, how often are these standard terms found in our professional articles today? Instead, a strange hybrid expression, one not even mentioned in the new glossary of forestry terms published by the Society of American Foresters, is used to cover any or all of these terms indiscriminately. In this respect, the U. S. Forest Service, which prides itself on holding the leadership in all forestry matters in America, and probably rightly so, is one of the worst offenders. It is a stickler for the proper use of names for tree species even when they are as ridiculous as the use of "red pine" for Norway pine, but when it comes to silvicultural terms they ignore them all. Everything is called "selective logging."

Chapman has already called attention to some of the objections to the obnoxious use of this term[1]. His arguments were rather against the practice than the use of the term, but they bring out some of the objections to it.

As the term "selective logging" is nowhere exactly and authoritatively defined, it can have no definite meaning. Possibly the history of its development would throw some light on it.

Studies of the cost of logging showed conclusively that logs below a certain minimum diameter could not be taken out of the woods at a profit. Of course, that diameter varies with different species of timber, with different logging conditions, and with different logging equipment, but in every ease there is a minimum size below which the logs come out at a loss. In other words, it is possible to remove from a stand only the larger trees and make more profit than when all the trees are taken. It is an economical method of logging. As such no one can object to it.

In most cases this practice would result in leaving the smaller trees. That was the beginning of the trouble. It seemed reasonable to believe that lumbermen would readily agree to a method that would save them money. As an added inducement it was pointed out that the stand that was left would grow rapidly after this heavy thinning and would provide a second cut in a comparatively short time. With a little wishful thinking it was easily possible to conceive of the owner's being definitely interested in permanent forestry practice by the time he had waited for the second cut. A little more of the same kind of thinking saw the land producing an equal cut ever so often, and behold! they had a sustained yield!

With true American enthusiasm and an utter disregard of the facts of life, all the old methods were thrown overboard, and "selective cutting" was hailed as the panacea for every ill to which the forest is ever heir. The silvical requirements of species were utterly ignored and this same system was applied to mixed stands, pure stands, tolerant and intolerant species, fire types and climax types, regardless. As there was no definition of it, each enthusiast modified it a little and breathed into it the qualities necessary to meet his needs.

In no instance did it mean anything that could not have been much more adequately and intelligibly stated by the use of standard terms.

The conceptions of selective logging as a silvicultural system are merely desperate efforts to grab the tail of a kite that seemed at the time to give some promise of going up. No one looked to see what kind of a kite it was or whither it was headed.

If this almighty system was to be all that its enthusiastic supporters hoped, it was, of course, necessary to discard all other methods that did not agree with it. All clearcutting of any kind anywhere has become anathema. All government bulletins and most other publications look with horror on any method that does not leave a second cut on every acre. They point with great pride to the fact that a certain selective logging operation left 20 per cent. of the timber standing and made possible a second cut in a few years. They seldom carry it any further. They merely say that a second

[1] Chapman, H. H. "Selection" cutting in loblolly pine. *Jour. Forestry* 42:838-39. 1944.

cut can be made in 15 years, where clearcutting would have delayed the second cut for 100 years. They do not explain that it may be at least 100 years after their second cut before they can make a third, and may be far longer than that, because they have made no provisions whatsoever for the establishment of a new crop.

Let us see what will happen when this amazing system is applied to jack pine, or to any other intolerant species growing in a pure stand. If this stand were clear cut anew, fully stocked crop would be established at once. But instead of clearcutting, it is "logged selectively"; 10 cords per acre are taken out, and five cords per acre are left. If no sleet storm or wind storm comes along to snap it off, this remnant is supposed to grow at a greatly increased rate and produce a second cut of 10 cords in 10 years. Thus, it produced five cords more in 10 years. The stand would have done better than that if no first cut had been made. As no one has explained what will happen after the second cut, the writer will venture to predict.

Contrary to assumptions of the selective loggers, there will be no reproduction following the first cut. Hence the land will support only a fraction of the normal growing stock for the next 10 years. And as jack pine is very slow to recover from overcrowding and to build up a large crown the increased growth will not be realized. But the first cut will accomplish something. Except on the very poorest sites the opening of the stand will encourage a dense growth of hazel. By the end of 10 years, when the time comes for the second cut, the brush will be so dense that reproduction cannot be established by any method that has been discovered as yet. What has been gained by "selective logging"? This is an extreme case but it has been advocated very strongly.

Let us be sensible! Let us stick by the old established terms; call a spade a spade, and a thinning a thinning! Let us not chase after false gods till they have shown their credentials and can produce a pedigree longer than 10 years!

—*Journal of Forestry*, Vol. 43, No. 3, March 1945.

VOLUME 72 NUMBER 6

INDIAN FORESTER

JUNE, 1946

WAR COMES TO THE DOON FORESTS

(A Postscript)

BY F. C. FORD-ROBERTSON, I.F.S.

(Conservator of Forests, Fuel and Transport Circle, United Provinces)

It is all over now and the lovely *sal* jungles are licking their wounds and getting cleaned up. All, that is, except the historic portion right in the very centre, where, I am told, the Tactical Training School are still doing their lethal stuff with tanks and mortars and flamethrowers. And if I, who was the divisional forest officer in charge, do not tell the tale of those hectic war years, no one will and something will be lost, buried fragmentarily in terse and soulless entries in the bulky compartment histories and in those stereotyped annual reports that, because they are compilation fodder, no one save the drafting divisional forest officer ever reads. That something, I venture to think, is worthwhile recording. Others can and I hope will, tell us of more exciting and hazardous forest working with the enemy at their very threshold—in Bengal, Assam and North Burma. The Doon, the peaceful delectable Doon, lies far from all that. But war has long, grasping fingers and clawed long and greedily at the United Provinces forest reserves and nowhere longer nor more deeply, I believe, than at those cradled in the Doon valley. Just how that challenge was met should be of more than professional interest. For the Doon forests in their fifty-five by seventeen mile valley are probably as well known, both to foresters and the lay public, as any in the land of India. To the former because they have been the nearest and chiefest training ground for successive generations of forestry students both from British India and the States—the "home coverts", as it were, of the forest colleges; to the latter because of Dehra's growing popularity as a resort and the exceptional facilities for *shikar*. If I tell my story in some detail, it is with these circumstances in mind and in the hope that the greatly expanded classes of the postwar period, who will tour and camp in these forests may study them with heightened interest and realise more clearly the impact of war on a fine and highly organised forest estate.

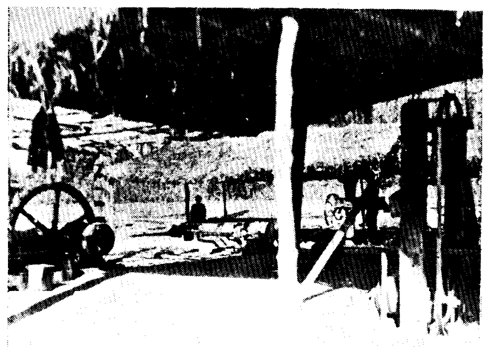
So now to it. But first and for essential background, a little forest history. When war broke out, the Doon reserves, some 300 square miles of generally compact forest, much of it almost pure and well-stocked *sal, (shorea robusta)* had been under regular management for nearly seventy years and under working plans for over half a century. Fernandez's was the first comprehensive plan (1888-1902), chiefly improvement fellings —they were *needed!*— and cultural operations. It ran its full course, to be followed by Milward-Jackson's (1903-26) which superimposed 6′ b.h.g. selection fellings and tried two important experiments in management. One, which was not persisted in, prescribed coppice-with-standards working in certain accessible areas S. and S. W. of Dehra; these, some 30 to 40 years later, yielded magnificent *ballas* for the Moloch of war—of which more anon. The other, which made forest history, started conversion-to-uniform on the rich terraces of Thano—the earliest application of this system to *sal* in India. Bhola's plan (1923-4 to 32-3) saw this system extended to all the workable—and some barely workable—*sal* forests and was thus responsible for the unique and enormous *balli* (pole) potentiality of the division during Hitler's war. The fourth working plan, Champion's (1931-2 to 40-1) together with the fifth and latest, Sen's (1941-2 for ten years) continued the process of conversion in all save the hill type of *sal* with an increasing elaboration of tending work in the ever multiplying and developing cohorts of saplings and poles, the well known P. B. IX's and VIII's of the current plan. It is this steady succession of working plans, carefully prosecuted for their

prescribed period, along with the massive emergence on the ground of something approaching text-book conceptions of the conversion process that make the forests of the division such a valuable training ground for the student and a "show place" for the foreign professional visitor; and that render it such an exacting but highly attractive charge to the keen forest officer—if he has peace to work in. The writer, of course, was cheated of that. But I anticipate . . .

War, in the form of demands for special categories of timber, hit the Doon early, and characteristically, it began with *ballis*—extracted in the rains of 1939, the first essay at monsoon working. We were soon, to get used to that. Then, with the launching of Sen's carefully conceived working plan, the real blitz started and by the end of its second year (1942-3) most felling tables had gone by the board and the dictatorship of the D.F.O. began. It was the same in every U.P. *sal* division, no doubt, and each D.F.O. had his own plan and his own problems. I remember sitting down over mine with my maps and doing a long 'think'. If one must exploit—that ugly word—how best to set about it with least harm to these famous forests? Two big advantages I had. First, of knowing the Doon *sal* from my early assistant days under Bailey and later as provincial silviculturist, and so appreciating the crop implications of their long history of management. This had actually built up, over slow decades, a reserve stock of fine big *sal*, and also *sain* (*Terminalia tomentosa*) in the intermediate P. B's, which before the blitz struck us had added to the text-book 'triangle' of the normal forest an invaluable lump of 'fat'. Secondly, nearly two-thirds of the circle had recently been enumerated so I knew just where the big stuff was. The Doon *sal*, in short, were more camel in outline than hyaena and I could carve the hump with precision. And not solely in terms of big timber: for a lag from the previous plan in adequate cleanings and thinnings of the now extensive young age-gradations stood ready to add a further axe-fall of smallwood and fuel if needed. It was. Every maund of it. Never were forest "reserves" more aptly named than those of the Doon at the outbreak of war.

On this knowledge, then, I based my general strategy of exploitation. Each year the prescribed coupes of the plan would be marked—all yield is controlled by (equalised) area—and every intermediate compartment would have all silviculturally available *sal* and *sain* above 20 inches b.h. diameter removed instead of the 1 : 6 proportion conservatively permitted under the plan. When this fell short of the demands made on us—as soon was the case—additional intermediate compartments from much later coupes would be selected and marked in the same all-out way. Serious gaps in the canopy were not allowed, although, of course, mistakes occurred and some smashing of unmarked trees was inevitable; while at all times the 'approach' class of tree, *viz.*, 16″-20″ b.h.d. was carefully conserved. By the fifth year of war we had in this fashion pretty well worked out our intermediate areas, completely so in the eastern Doon. That is why the tall massed glory of the Thano and Barkot jungles—so predominantly of this category—has departed; and the student who wished, and I hope many will wish, to know what they looked like before war's greedy harrow passed over them should visit the hundred odd acres of fine P.B. II in Ramnagar block before the plan reaches there; for P.B. II, the preparatory stage of regeneration fellings, was kept sacrosanct along with the nursling P.B. IX's, and proceeded solidly by the book.

The above strategy, designed to protect the main structure of an elaborate and costly working plan against a huge timber demand, unfortunately broke down when other and concurrent demands beset us. Thus it could not produce *ballis* in any quantity. And its catchcrop of fuel was chickenfeed besides the colossal amounts expected of the division from 1944. These latter years forced us to advance fellings of fuel-rich P.B. I's and selection circle areas in the remoter blocks, enabling us to clear out a lot of accumulated moribund rubbish from the latter. But the *balli*-blitz, as we in the Doon called it, quite defeated us and caused exploitation and deviation in the very worst sense of these words. When this blitz descended on us in 1942-3 we were ordered to go into immediate and unlimited production "and no red tape restrictions." Previous to that we had met *balli* indents by orthodox and genteel thinnings; now drastic measures were called for, we had neither the time nor the staff for hammer marking nor could this possibly have met the emergent situation. So we evolved a system of letting reliable

Figs. I and II. A small forest sawmill set up to meet hot-weather sawyer shortage and the early hutting orders. Oil-driven; $2\frac{1}{2}''$ band saws. Had three locations.

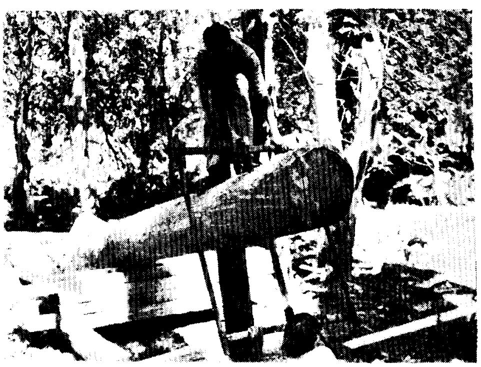


Fig. III. Skilled Saleempur sawyers; these men produced first class work right into June. Note the typical frame-saw.

Fig. IV. Ballis piling up at depot. (Lakhibagh, 1942.)

SAL WHARF BEAMS

Fig. I. In the forest. A rush order being hand-swan departmentally.

Fig. II. Coming out the old way: one beam, with luck, per day.

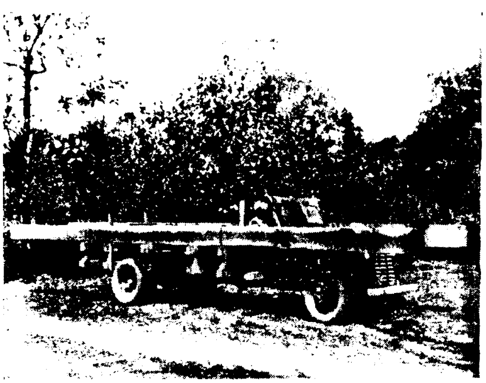


Fig. III. Coming out the new way: eight beams, in four trips, daily.

Fig. IV. Man-handling at depot. Big beams took forty men or so.

contractors loose in our precious P.B. VIII's (the while some distinguished forest officers turned uneasily in their graves) to fell and extract to depot any pole they considered would pass the Defence Department specifications. Fortunately, as has already been noted, some of our contractors had already acquired *balli* experience and with these as a nucleus the show started. New men studied their work and were roped in, and with initial coaching they soon learnt what to take; under their agreements, of course, they received nothing for rejects (which remained departmental property) and had all the expeness of their cutting and carriage. Soon, in order to increase the output while saving some of our P.B. VIII's, we extended the system to removing *ballis* from the large accumulation of suppressed poles so characteristic of the well-stocked intermediate P.B's, choosing wherever possible those areas where previous heavy fellings of selection trees would allow most light to the coppice. Either kind of *balli* felling we all cordially hated and they were known and referred to, even officially, as "*zamindari*" fellings (private forest owners please note). But they delivered the goods and that was what mattered most. All that season, despite other preoccupations, my staff and I talked and wrote and dreamt of *ballis*, as the *leit motif* of our existence —every range was toiling with them—and by the end of it we had produced well over a million (*see plate* 15). That was the peak season but Dehra division was an important supplier throughout the war. Here are some production figures—

Year	*Balli nos.*	*Sizes*	*Remarks*
1939-40 ..	1,26,000	12′ to 16′ long, chiefly, and 3″ to 7″ mid diameter under bark	Some lakhs of *zamindari* ballis were also handled.
1940-41 ..	3,18,500		
1941-42 ..	2,21,500		
1942-43 ..	10,61,500		

Looking back on these hectic years, against the main background of all-out timber production it is curious how one associates each working season with some special supply. For me, it runs thus—

1940-41 : Early *balli* orders.

1941-42 : S. G. and Decauville sleepers; charcoal unlimited.

1942-43 : Wharf beams and *ballis* unlimited.

1943-44 : B.G. and other track sleepers; fuel.

1944-45 : Log orders plus FUEL unlimited.

The wharf beams were an early and peculiar anxiety. A thing 35 feet long and, say, 13 inches by 14 inches section is nuisance enough to saw but a positive headache to load and transport from dense forest. One contractor broke five carts under one outsize beam and did no good to his teams; another, in consultation with us, brought and adapted a motor lorry for transporting these unwieldy bits of wood and became one of our most successful suppliers (*See plate* 16). There was always such urgency attending the delivery of these beams that we used to heave a sigh of relief when each B.F.R. or "Bogie Flat Rail" wagon connected with its load and disappeared down the line. Like getting a splinter out of one's foot. One of these B.F.R's, it is pleasing (now) to recall, got mislaid on the railway, leaving our hands on a hot April day in 1942, ostensibly for the Manganese Depot, Bombay and turning up at New Delhi on a still hotter April day in 1944, whence it reached its rightful destination, we heard, the same July, with contents somewhat short of their original 370 c.ft. but doubtless well seasoned. We collected a wonderful multilateral correspondence about it, quite the choicest of our files, before the Bogie was laid to rest.... These were the days, of course, when D.F.O's struggled along with their own despatching depots;* we had six or seven on the E.I.R. and one on the N.W.R. away down at Saharanpur, a wide dispersal not without its advantages.

Our most unpopular supply by far, however, was that of *ballas* for transmission poles. Take the very finest—the best grown and best quality—of your younger *sal*, cutting them off "at thirty-six feet and thirty-six years" and you have a *balla*. The specifications were stringent, of coniferous calibre, and even allowing for some relaxation, one had to pick and choose so carefully among the crop lest a reject should make the murder a mockery. They were nasty things, too, to get on a cart and keep balanced there; a pair of them frequently broke the carts—or the oxen's hearts—while single ones slowed down delivery and rocketted costs. The job, of course, was done departmentally and if I remember rightly at a financial loss. In all we can have supplied less than a thousand but because so few could come from thinnings—even *éclaircie par le haut*—they felt like drawing a tooth. Fortunately higher authority did not care for

*Special Timber Supply divisions were formed in October, 1942.

sal ballas either and latter and less emergent indents were met in other ways.

The producer-gas 'flap' of 1942 sprang on us round about the time that charcoal burning closes down in the best regulated divisions and caused us high diversion and some jungle jitters throughout that hot weather. As with *ballis* the following season, production was to be "all out", so I sent men scouring the adjacent hills for burners, to pull them back to work, most unseasonably and *bedastur,* in our miscellaneous forests. The division has never done much charcoal burning, partly because the local *zamindari* forests with their laxer conditions of working attract most of the specialised labour, but eventually we achieved quite an army of workers, mostly Dhotiyals, and all through the hot months the jungles smoked like curing sheds from hundreds of kilns (*see plate* 17) while Dehra folk wondered and sent me anxious phone calls. My staff and I felt anxious too. However, our luck held, we started no conflagrations and finally we delivered a record total of 78,000 maunds of short-notice charcoal at depot. It was an effort that allowed the hard-worked staff no hot season respite but at least it cleared our miscellaneous low-level forests of an age-old accumulation of worthless, overmature or misshapen trees and silviculturally did more good than harm.

The same cannot, unfortunately, be said of the special orders for *tun* (*Cedrela toona*) logs for aeroplane plywood, which came later nor those for *gutel* (*Trewia nudiflora*). The former, in particular, constituted a very real depletion of our miscellaneous forest capital, the exploitable diameter having to be lowered to 20 inches b.h.d. to meet the urgent demand. I contrived to save one magnificent patch of virgin timber (students should try to see it—in Golatapper 7*b*) but the rest had to go. Logs are an unusual and therefore highly unpopular form of timber supply in the Doon but we contrived to deliver over a lakh of cubic feet of them—*sal, sain, tun, gutel* and *bakli* (*Anogeissus latifolia*)—to assorted specifications, between 1942 and 1945.

All these sideshows, important as many of them were, remained just so many extras on our main preoccupation—the massive and almost continuous production of sawn *sal,* this along with its associate *sain* being a requisitioned species. We used to get our major allocations of Defence Department sizes before the rains auctions and then supplementaries would be bunged at us throughout the season, to be coped with as a rule by additional fellings. Before adjustments were made in the schedule of prices, contractors would find many ways of dodging "unprofitable" sizes allotted to them, so jeopardising specific war orders. They wanted, in short, to pick and choose, or even, if their sawyers were second rate, to saw their lots into bulk sizes at top speed and come back for more. And, later, when the smaller *sal* categories were released from requisition, there were attempts to saw down to these categories owing to their famine prices in open market. All this sort of jiggery-pokery had to be countered at all costs. So early on, and right through my time in Dehra, two officers, one a forest assistant, the other a ranger, had as their special duty this control of size production in the lot, with power to order re-sawing of delinquent sizes. Linked with this, we armed our big corps of stump moharrirs with measuring rods and taught them to maintain a stump-by-stump record of outturn, which was continually under field check: and very well they did it too. And we devised a specially printed form that shuttled between each range and the D.F.O. every half month, showing the production/export figures of every sawn and round timber order in every lot. These measures, combined with the constant inspecting never let us down and the special form was adopted, I believe, in other divisions.

And here is our record of timber outturn for these fell and busy years—

Year		*Total outturn by purchasers agency in terms of c.ft. sawn (figures rounded)*	
		C.ft.	
1939-40	..	5,80,000	(*Sain* 47,000)
1940-41	..	6,62,000	(*Sain* 59,000)
1941-42	..	8,64,000	(*Sain* 56,000)
1942-43	..	23,61,000	(*Sain* 96,000)
1943-44	..	19,73,000	(*Sain* 1,26,000)
1944-45	..	15,39,000	(*Sain* 1,68,000)
Average annual outturn for the previous decade		Nearly 4½ lakhs *sal* ; ¾ lakh of other species, chiefly *sain*.	

Out of these big divisional totals, we have already discussed the logs and poles and wharfage. Here is the tally for sleepers—

Defence Department Sleeper Production

Working season		Track Sleepers				Specials (N.W.R) and Crossing (C.ft.)
		M.G. (Nos)	B.G. (Nos.)	N.G. (Nos.)	Others (1) (Nos.)	
1939-40	..	55,000	Nil	Nil	Nil	7,300
1940-41	..	Nil	Nil	Nil	Nil	7,200
1941-42	..	Nil	20,100(2)	Nil	17,000	7,500
1942-43	..	1,02,500	36,900	Nil	15,000	1,85,900(3)
1943-44	..	1,42,800	62,600	11,200	6,000	80,700
1944-45	..	1,64,900	45,500	25,400	10,600	1,30,600
Totals	..	4,65,200	1,65,100	36,600	48,600	4,19,200

(1) *e.g.*, Decauvilles, B.G. and M.G. blocks.
(2) includes 9,100 S.Gs.
(3) *60,000 c.ft. of wharf timber and 38,000 c.ft. of bridging sizes reduced sleeper outturn in 1942-43.*

The sudden spurt in production from the autumn of 1942 needs no emphasis. Out of the total of nearly 17½ lakhs c.ft. of sleepers, over 15½ lakhs came out in the last three years of the war.

All this heavy timber production, a total of almost 80 lakhs c.ft. in six years, naturally brought with it great quantities of fuel. In some less accessibly situated divisions much or most of such fuel just had to be left where it lay, to clutter the ground and jeopardise the forest. Not so in the Doon. Even in peace time there had always been a considerable local demand, not only from the townships of Dehra, Hardwar and Rikhikesh but from tea factories and lime kilns, and, since 1935, also from the nearer sugar factories in the plains. In the decade before the war consumption averaged eight lakhs of c.ft. or say 10 lakhs maunds each year, with a tendency latterly to rise. Conditions created by the war caused the demand, both from within the district and without, to intensify sharply, until in the last two years, when the Doon was supplying Imperial Delhi, the Punjab military (10 lakh maunds) and numerous plains towns of the U.P. on a sort of rota at fixed rates, the only limit we knew was labour and transport. Even the canal to Roorkee was tried for porterage but had eventually to be ruled out. There was even a fuel crisis in oak-girt Mussoorie, over-looking the Doon from its 7,000 ft. ridge, and until the writer could organise controlled fellings in its wealth of small private estates, many a hearth in that Queen of Hill Stations was warmed by fuel taken up from the Doon. But that was a mere shrimp in a whole shoal of supplies—fuel to the big P.O.W. Camp at Clementown and the Internees' Camp at Premnagar, to the swollen military establishments in Dehra, to Lahore Military District (Lordist) *via* long convoys of their own M.T., and so on. Outside soldiery—I am discreetly vague—also sometimes helped themselves from contractors' road dumps in sudden lorry raids, generally under cover of darkness; and undoubtedly, despite our check *chaukies* on the Siwalik road passes, which were established as early as 1941 with a police guard, a fair amount got smuggled out that way to feed the hungry black markets in the plains. Here, in round figures, is the record of our war outturn, certainly the highest in the U.P.—

Year		*Fuel outturn in maunds** (82 *lbs*). *by purchasers agency.* Mds.	*Remarks.*
1939-40	..	16,00,000	Excludes fuel removed by right-holders and concessionists.
1940-41	..	14,00,000	
1941-42	..	14,00,000	
1942-43	..	21,00,000	
1943-44	..	47,50,000	
1944-45	..	49,00,000	
Grand total	..	1,61,50,000 mds. for six years.	

*These are not the figures of the Annual Report which are tied to formal factors, *viz.*, one cartload=10 c.ft. solid fuel= 5mds. A Dehra bullock cart takes an average of 15 mds. In the overload of war it often took much more.

Comparison of the above three tables shows that timber production decreased latterly whereas fuel continued to rise, following a shift in emphasis from one to the other, as reflected in our marking programme. In general, forests of poorer quality and condition were selected in the last two war years. Unfortunately this also meant much longer leads.

To these big totals the various *zamindari* estates of the Doon, which—with a few honourable exceptions—were ruthlessly skinned by their owners, added a few lakhs of maunds each year. From 1944 all this went into our controlled firewood pool, the Doon Valley becoming a gigantic sort of fuel bin for a large number of consumption centres in the plains. Fuel stacks cluttered every road and ride and lay in ambush dozens deep along the wooded highways of Timli, dominating the forest scene. Despite, therefore, its large internal consumption, probably exceeding 15 lakhs maunds per year (of which half was on military account) fuel was flowing from the Doon in enormous quantities throughout the war. Thus, during 1944, rail export from Dehra line stations, excluding Hardwar totalled 9,565 broad gauge wagons or over 31 lakhs of maunds of firewood.

A word must be said here, for the student at least, about the important fuel contribution, much exceeding the *zamindari*, made by our varied and widespread cultural operations during these years. It has already been indicated that the new plan, which started in October 1941, prescribed very intensive tending works in our various periodic blocks, so intensive that I have heard them described as "almost gardening"; and so extensive that, even on the normal felling cycle, they covered very many thousands of acres annually. From early on, the rising fuel market saw that these culturally treated areas were swept clean of their cut material; so the heavy programme was continued and as, in the course of time, fuel became a war priority, we struggled on with it, taking up the deviation felling areas too and dropping only non-productive items like special climber cuttings. As a result, the vital cultural work of the new plan was, followed in all important respects, an achievement in which the whole staff took pride; and in this way we wrested a dividend from the wasteful war. Its token value in mere cash swelling with the years, can be realised from the following table:—

Year.	Gross revenue from cultural material (figures rounded).	Remarks.
	Rs.	
1939-40 ..	8,000	Before 15-11-1944 the controlled price of fuel was -/15/6 per 82 lbs. maund f.o.r.; thereafter 12 annas.
1940-41 ..	26,500	
1941-42 ..	27,000	
1942-43 ..	32,500	
1943-44 ..	2,47,000	
1944-45 ..	2,23,500	

The cultural dividend had even a war bonus to it, for we were opportunists and when an area fell due for treatment, we swept into our basket the clutter of old girdled trees, some dead, some still struggling on, of bygone overwoods and the hollow fallen boles from decades-old fellings. While, in the remoter forests of the Western Doon, we joyfully got rid of numerous ancient and incredibly decrepit *sal* and *sain* that were cumbering later crops and which no one in the past had known what to do with. From Sahaspur block alone, nearly 2,000 of these lingering relics were removed, the massive hollow "guts" (I am being vernacular, not vulgar) of the boles being sold to brick and lime kilns. Even fig trees joined the holocaust, though these were latterly dealt with during main fellings, the contractor being bound to fell all marked and listed *bargat* and *peepal** on pain of penalties. Sainkot block in the Barkot range came in for special treatment this way, to the enduring benefit of its fine quality *sal*.

Another forest liability, Dehra's fifth columnist, the Longicorn beetle (*Hoplocerambyx spinicornis*), also came in for a rough time of it. Students will recollect that this formidable pest of *sal* has always been endemic in the Doon, especially in the Thano reserve, that it caused havoc in the twenties there and has been countered ever since by the routine disposal of every sawdust-spilling *sal* every cold weather and the departmental burning of slash. 1941 was the last time we had to do that. Thereafter the weather combined with the rhythm of our rising fuel utilisation to scotch the menace. Both 1942 and 1943 were years of heavy and continuous monsoon rains (92 inches and 117 inches respectively from June to September), conditions which favour a rapid increase in Hoplo. numbers. At the

**F. bengalensis* and *religiosia* respectively.

same time both saw the forests cluttered up with masses of lop and top—the inevitable carry-over from contractors' timber fellings of the previous hot weather. I found this material simply infested with Hoplo. larvae after the rains and it was all cut, stacked and exported *ad flammas*—a gigantic trap nest—by December. In the succeeding years hardly a tree could be found attacked through the length and breadth of the forest. "It's an ill blitz...."

One other protective activity that we were at pains to carry on throughout the war years was the lopping of big-crowned marked trees so as to reduce felling damage. This practice had been followed, off and on, before the war, men—generally Gurkhas—being found ready to risk their necks in this fashion for as little as one anna per tree. The heavy and necessarily less controlled fellings of wartime intensified the importance of such lopping but beggared us of the specialised labour. So we turned to that old Doon incubus, the migratory lopping Gujar, whose depredations have become an increasing menace to the hill and miscellaneous forests, and compacted with him to lop, free or at nominal rates, so many marked *sal* (which his buffaloes ignore) in return for so many marked *sain* and *bakli* which they gobble, in the knowledge that Dehra contractor agents were paying him five to six annas a *seer* for his milk at his tent door. The idea speedily caught on and in this adventitious way we contrived not only to get thousands of the biggest canopied trees lopped for a nominal sum every year, to the salvation of the rest of the crop, but also saved a lot of illicit hacking, while contributing to Dehra's all-too-short milk supply. This *quid pro quo* expedient should have a future in the post-war period, whether the migrant Gujar is admitted to the Doon or not: for the local villagers have long learnt to "go upstairs" for their buffalo fodder and the department should provide whatever it can in a legitimate way. During the cutting back of regenerated Conversion Circle areas, too, a similar influx of cattle was actively encouraged to utilise the fodder freshly cut by our cultural gangs.

All these major activities, of course, were not the only ones in the way of production. The Doon forests are rich in many things besides their 'big shots', *sal* and *sain*, and these, too, the war demanded in full measure. A modest but steady output of *sissu* (*Dalbergia sissu*) for instance, from the riverain forests; quantities of *bakli* logs from the hilly areas; a 2,000 tree annual selection felling of *khair* (wisely suspended in 1944, to relieve the strain on manpower and transport) and a considerable range of minor forest produce. Grass, for example—*baib* (*Eulaliopsis binata*) from the Siwaliks, on lease to paper mills (98,000 maunds in three seasons) as well as the coarse thatching grasses of the flats, the local demand for which, chiefly on military account, rose steadily; until in 1945, the vast, lonely "tappars" of Barkot range were, for the first time in history, shorn clean, not by the usual departmental firing but by the contractor's sickle: And very nice they looked....Some 50,000 maunds went in this thrifty way in the last year of the war, to shelter its practitioners.

Even the larger Gramineae, the bamboos, which admittedly cut a poor figure in the densely forested Doon—our depressed classes—came into the picture. The well-known Lachiwala exotics, *Bambusa tulda*, *Thyrsostachys* and the rest, flowered gregariously in 1939-40 (no doubt from war shock) and went the way of all flesh and fibre at amazing prices; while I remember the accessible Motichur hills yielding over 17 lakhs of the indigenous *Dendrocalamus* in 1942-43, a lusty war baby which burst its cradle, for carts could not cope and we were reluctantly compelled to allow dragging. The Lachiwala exotics, I am glad to record, received the funeral honours that were their due and with careful tending inside a wire enclosure their flourishing progeny bid fair to restore something of their remembered loveliness.

Canes (*Calamus tenuis*), hitherto an almost neglected product, also thrashed their way into the limelight from 1943, for supply-dropping containers, and all the eastern Doon brakes got cleaned out, to the annoyance, no doubt, of the local tigers whose favourite haunts knew little enough peace already from the peripatetic jungle warfare units.

Finally, by virtue of our nearness to the Forest Research Institute we from time to time got stuck with finicky and time-taking departmental supplies for research purposes-selected logs of odd species, sections of bamboo and cane, dried *baib* grass and bamboo for pulping experiments, dried bark of various trees and so on. Reminders that, although divisional

research was curtailed, the Central Institute was pulling its weight in that important sphere.

All this greatly expanded working, in the Doon as elsewhere, threw an increasing strain on the staff, to which they responded nobly. At first the normal pattern of U.P. forest working could be followed, with the usual rains auctions and contracts finishing in March, or early April, allowing some hot weather respite to everyone. But soon the increasing timber demands together with the unseasonable times at which urgent Defence Department orders would arrive, involved us in extra markings and subsidiary sales, and hence more and more working into the hot weather. In 1940-41, for example, we managed with two or three subsidiary auctions and finished the season betimes. By 1942, as the pace grew hotter, numerous lots were working over two seasons, including the whole hot weather, their sawn orders coming out in the first season, the remainder of their stuff the next* and this state of affairs necessarily continued *crescendo* to the end. The division, in fact, eventually had demands on it far outstripping its labour and transport, with conversion pausing only for the rains (lots adjoining *pakka* road sometimes excepted; but the sickness rate, especially in the more malarious Eastern Dun was daunting) and marking, cultural operations and sales became an incessant treadmill. Let me here and now pay tribute to the devoted band of marking officers and cultural jemadars who worked such long hours and long seasons and could avail only a curtailed vacation. There were never enough of them, yet always, it seemed, too many for one to get round to them often enough. All D.F.O's in similarly hard-pressed divisions must have felt that. By my last year the regular M.O.'s had got diluted down to two deputy rangers and three foresters plus seven forest guards officiating as foresters, and there was no month, save August, since 1942, that the sound of the marking hammer could not be heard somewhere in the Doon forests.

The cultural jemadars, men deputed and trained, by long custom, from the cadre of forest guards, never worked quite so continuously as their marking brethren—coolie labour being a bottleneck—but the expansion of their work can be judged from the fact that sanction stood at 22 c.j. months in 1939-40 and 128 from 1943 onwards, a nearly six-fold increase. The old distinction between them and the marking officers, I should add, became blurred latterly, inasmuch as the jemadars were allowed under the pressure of circumstances to mark and not cut down unwanted stems over 4 inches b.h.d.; and still more so when, as already mentioned we seized the opportunity to bring great numbers of old relict trees in these cultural areas to war's insatiable fuel market.

I used to make a practice of keeping at least one small cultural gang at work in each range throughout the hot months, to supplement the non-stop marking gangs as fire fighting nuclei. It was a policy that paid. And this brings me to the subject of fire protection, a subject important enough in peace-time but of vastly greater moment in war, when forests are at all seasons full of priority Defence Department timber and no less precious fuel. From April to rainsbreak, fire was our Public Menace Number I, not only to the produce itself but to the forest from which it came and which it could involve in common holocaust.

Fire has always constituted a pretty sizeable headache to D.F.O.'s of the Doon. Long years ago it was recognised that the chief danger came from south of the Siwalik ridge, from invasive fires sweeping over—and "sweepping" is the right term to anyone who has witnessed them in a *loo* wind—from the hot dry slopes of the adjacent Saharanpur division where graziers have a bad reputation for incendiarism. This chronic danger had been first countered away back in 1888 by cutting the well known Hathiwala fireline and, again, much later, under Champion's plan by a second 100ft. line laid roughly parallel and somewhat above the original one. Behind and below this zone of defence, the valuable Doon forests have sheltered fairly successfully for over half a century of organised fire protection, with failures ranging for the most part between ·5 and 4 per cent. of the protected area. In the later thirties a practice had also grown up of control burning the tangled precipitous terrain between the main ridge and Champion's line; but this had not kept out large fires in 1939, such burnings could only be called 'controlled' by courtesy and the new plan had wisely discontinued them

*Late fees were clamped on extensions on a 15-day rising scale, to discourage calculated delay; this had a salutary effect.

as unwarrantably damaging to the sparse but precious forest protecting that erodible upper zone.

This, then, was the situation when the writer took over. This and then worse. For the war soon turned the Doon into a military Mecca, filling it with soldiery training here, there and everywhere, the jungle for preference, and carrying plenty of "fire-power" in their hands with no close season to it. These together with our own hot weather activities constituted a formidable internal danger. But we had still more to think about when the 39th Division established themselves in full war panoply along the whole length of the Siwaliks on the dry Saharanpur side, greatly intensifying the old danger from without. It seemed we were facing a special jungle warfare of our own, on two fronts.

Something had to be done about it : so, early on, my staff and I went into a huddle. Our chief worry, we decided, lay in the magnified menace from the south, with the likelihood of frequent invasive fires on broad fronts. We knew from past experience that only a proportion of these could be stopped at the 100 ft. fireline, that, in short, counter-firing parties would sometimes arrive too late ; also that the line did not run the whole length of the fifty-five mile front *e.g.*, in the Motichur range. Field telephones for a mere civilian show like ours were not to be had (I tried it) and our best in the way of fire-towers consisted of a 20 ft. ladder up a modest sort of tree at Sahaspur *chauki*. Somehow the fire-watchers posted at points along the Siwalik ridge every April—our chief alarm bell—had to be linked up quicker with our counter-fire organisation. Typically, under existing conditions—and I know this will sound completely prehistoric to any American who reads it—a lookout would come pattering down five or six miles of wild jungle path, often at dead of night, knock up the staff and go pattering back with the summoned gangs, who might arrive too late and would certainly arrive considerably tired. This Hill-billy *bandobast*, we all felt, did not match the current emergency. Somehow and as soon as possible we had to ginger it up.

As a beginning, the location of the ridge look-outs was carefully reviewed, additional ones appointed and every post (there were day and night shifts) co-ordinated with fire sections below, each section under a range assistant. Next we sought to improve communications. And here we had something definite to build on. Dehra division is blessed —or cursed, it depends on your point of view—with a system of light *kaccha* motor roads, built in the thirties to facilitate inspection, and in the western Doon a few offsets to the main sub-Siwalik motor road ran up to one or other of the firelines. These we decided to improve and extend and to construct others in each range, with the idea that fire-fighting gangs, lorry-borne and fortified with water, rations, tools and first-aid kit could be rushed to any threatened Siwalik sector fit and fresh and in the minimum of time. Preliminary surveys showed that many such fire-control roads could be made, not only up to the upper fireline but considerably beyond (one, in the event, proved an easy alignment right up to the Siwalik main ridge). And this gave me a further idea—to establish yet another and primary line of defence much nearer the ridge and extending the whole length of the division.

As rapidly as staff and labour permitted these twin projects were put into effect, year after year, until by 1945, we could boast a carefully aligned 20 foot *batta** running from Motichur in the east to Dhaula in the west, backed by a complete system of fire-approach roads, fifteen in all : and on our now more or less triple defence line, we were at pains to improve the difficult lateral communications, always an important factor in successful fire-fighting, by step-cutting and aligning paths across the innumerable ravines. One final touch we were baulked of by war stringency—providing each look-out post with at least one bicycle ; that omission will no doubt be remedied now.

So much for the external menace. The internal one offered less scope for enterprise but we did what little suggested itself—increasing fire patrols, clearing every compartment and sub-compartment boundary line yearly instead of at intervals and control burning wide strips round hot-weather felling areas congested with Defence Department material. The weather apart, there is no doubt a lot of luck in fire-protection but at

*Cleared counterfiring line.

least we felt we were propitiating the fickle Goddess and that the almost complete immunity our produce enjoyed throughout these anxious seasons could not all be set to her credit. It is of significance and promise that, in the last two exceptionally dry and hazardous hot seasons, out of seven fires that swept over from the south, only one broke through our defence-in-depth and that on such a negligible front as to be speedily contained and extinguished.

As can be imagined, all these new fire-approach or fire-control roads lent themselves to important secondary uses. The division's 120 odd miles of light motor roads were neither intended nor constructed for anything save cars, and touring officers and contractors alike had always employed carts or camels for transport on an old-established system of export *likhs* (*kaccha* roads). Lorries were plied only on the public highways leading into Dehra, *i.e.*, on hauls from contractors' roadside depots. But the rising tide of the war demand soon overtaxed the cart capacity of the district, camels more or less disappeared—contracted to military work—and in the resulting bottleneck, transport prices soared fantastically. There was only one thing to be done and by 1941, the first lorries were rolling along our sacrosanct forest roads with loads of priority timber. They were the vanguard of a motley army. Our roads necessarily run athwart the lateral drainage system of the Doon valley so the numerous little bridges were a first anxiety, dozens having to be hurriedly redecked and underpinned to take ten-ton loads (*see plate* 17): then the road surface, once so carefully cambered and grassed....we never could overtake the awful punishment it took. In the last two hectic years, when well over a hundred lorries, often regrettably overloaded, were incessantly running, even in the hours of darkness, plus military transport that included rip-roaring jeeps and staff cars, yes and even stray *tanks*, we could only wearily dump river gravel in the more lethal holes and let the traffic pound over it. As during that time the writer broke eight car springs and his assistants more, we needed no old *koi hai's* of Dehra to remind us as they repeatedly did, that " a fellow can't enjoy a decent run in the forest nowadays". Military cars broke springs too, we heard, but their drivers didn't have to pay for them nor replace them with *kamanas* from some superannuated *tonga*!

But I digress. If we failed to maintain "pre-war quality," we could and did increase quantity where the needs of export and rapid inspection demanded. The Lachiwala, Barkot and Thano ranges, for instance were linked up through the superb *sal* forests of Ghamandpur, now, alas, ravished of their finest trees; and away at the other end of the division there was a road in Dumet, that remotest of the Doon reserves—then practically virgin—which crawled year by year up into its rugged hilly heart in a painful, labour-starved way, emerging to a triumphant conclusion in 1945. It, too, served its turn. But the new fire-control roads proved the most valuable of all, for they penetrated a Siwalik zone where past exploitation had been light or non-existent and released rich harvests of small timber and fuel to the new form of transport. By the end of 1945 the division could boast another 60-70 miles of motor road and was opened up to inspection and export as never before.

Labour and transport; these are the catalysts of forest working, and in wartime, just when he needs them fivefold, the D.F.O. seems starved of them. Our besetting trouble in the Doon lay in the perpetual counter-attraction of expanding and not to-be-denied military works—the construction of a vast prison camp holding 16,000 Italians and their guards: another one for thousands of internees; expansion of the I.M.A. and the cantonment area. And many others. All these works took labour and transport on conditions and rates beyond competition. Labour, of course, was drafted in by the thousand from Saharanpur side but these would seldom do forest work and even the military and P.W.D. contractors complained they could never get enough of them. At one awkward juncture lorries were even requisitioned and whisked away from my contractors almost overnight for some priority purpose. But I had one local ally. The Superintendent of the Doon helped me to some lease-lend lorries at one time and tried hard to procure me iron—the crucial bottleneck—in furtherance of a cart-building scheme we devised together. (One was willing, those days, to try anything). I know he filled in a lot of forms and provoked a pile of correspondence but when we met by chance the other day he told me he was still waiting for the iron. From the twinkle in his eye I gathered it had not entered into

Figs. I and II. The charcoal blitz: Two types of closed kiln going into production the oblong Saharanpur (Lachiwala) and the Karnal clay bee-hive (Motichur).

Fig. III. From light car to six-ton thela: a bridge in Balindawala gets underpinned for its war load.

Fig. IV. The D.F.O's car in trouble on war-worn roads.

his soul.... Then, latterly, the M. T. divisions came into being and brought welcome and dependable reinforcement to the contractors' battered array of lorries at non-profiteering rates—just at a time, moreover, when anything on legs or wheels that could move fuel and yet more fuel was being pressed into service. I recall more than one contractor, Motichur side, employing six varieties of transport between stump and station—lorries, carts, camels (decrepit rejects from military use they looked), ponies, donkeys and headload coolies. Somehow, some time, our stuff moved out.

Sawyers at one time or another proved a kindred problem especially in terms of quality, but like other D.F.O's I found their provisioning the bigger anxiety. Get the rations and you could get the men. Doon sawyers are, of course, imported—from the plains of Saharanpur and the Punjab, from Delhi, from the hills of Kumaon and Tehri-Garhwal and Kashmir—and various sorts liked various diet and were in a position to stand out for it. I remember one crisis, and so will my conservator and chief who were luckily on the spot and helped me to surmount it in unorthodox fashion, that involved wheat consignments from a distant State; and on more than one occasion a mass exodus of sawing labour was just averted in the nick of time. From 1942, indeed, everything became short—foodstuffs, petrol, paraffin, iron, medicines, stationery, even tempers; and we had to feed all imported labour on a ration scale, through the district supply officer. A small oil-driven sawmill which I encouraged an enterprising outsider to import and instal in the Lachiwala forests, also helped us out at a difficult period (*see plate 16*). It didn't clamour for wheat or grumble at the gram nor did it stop work in the rains. It was our great stand-by for rush orders, *e.g.*, the early hutting sizes hardly suitable for hand sawing, and it ran successfully at three sites over a period of years.

The general labour scarcity, needless to say was reflected in the rates demanded and paid for forest work. Before the war, ordinary *sal* scantlings cost three to five annas per c.ft. to saw; in 1944, 11 to 15 annas. Fuel used to be carted for three pies per maund per mile; the rate rose to one anna for carts and two for mules; grass from two to three rupees per 1,000 *pulas* (hand bundles) to as much as ten; and so on. Anyone who could move produce made good money.

But if costs rose steeply so did prices and despite government controls, which latterly pegged firewood as well as timber, there was enough money to be made, one way or another, to cause fierce competition among contractors. Our main auctions, which were held in the rains, used to become almost riotous and even a powerful loud-speaker sometimes failed to make itself heard above the *bannia* bedlam. After those two-day ordeals, from ten o'clock to 5-30, one would lose one's voice, if nothing worse. We took, of course, heavy security against speculators and what with that and our enormously expanding output, the police guard would sometimes tramp off to the treasury with a matter of lakhs. The tender system was tried out too, at times with ceiling prices, in an effort to hold the lid on inflation and keep the contractor body healthily solvent. To misquote—*Mal sana in contractore sano....* But it threw an additional burden on the hard-pressed D.F.O. and personally, if the remark may be excused, I retain no tender feelings for it.

The budget of the division during this time tells its own story. I give some major heads, both of income and expenditure, to show roughly how the money came and went.

War budgets, Dehra Dun Division

(figures rounded to nearest hundred rupees)

Item	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	REMARKS
R II a ..	3,11,900	3,66,000	6,56,700	11,31,600	21,05,800	23,00,200	
R II b ..	21,600	29,700	34,900	1,13,200	2,17,300	3,57,700	
Other heads ..	44,100	57,100	69,800	96,900	1,90,700	1,57,100	
Gross revenue ..	3,77,600	4,52,800	7,61,400	13,41,700	25,13,800	28,15,000	Average revenue for the decade before the war was $3\frac{1}{3}$ lakhs gross, nearly 2 lakhs net.
B 2 ..	7,700	10,900	17,300	1,17,600	36,000	38,400	
B 7 ..	24,700	18,300	24,200	35,400	33,700	35,500	
B 8 ..	23,300	24,300	17,200	23,800	39,700	43,700	
Other heads ..	5,400	4,100	4,500	4,800	18,600	12,300	
Total B exp. ..	61,100	57,600	63,200	1,81,600	1,28,000	1,29,900	*Revenue carried forward into 1945-6 exceeded 18 lakhs.
Total C ..	1,02,800	89,500	82,300	96,800	1,05,900	1,24,400	
Refunds ..	35,900	200	100	200	300	1,000	
Total exp. ..	1,99,800	1,47,300	1,45,600	2,78,600	2,34,200	2,55,300	
Annual surplus ..	**1,77,800**	**3,05,500**	**6,15,800**	**10,63,100**	**22,79,000**	**25,59,700***	

The RIIa figures include, naturally, large quantities of fuel. "Other heads" soared from 1943 with receipts from *ballis* (RIa); but everything growing or dead in the division seemed to become saleable—even dung in our forest *goshalas* for its legitimate purpose! Under expenditure, the rise in B7 is almost entirely under roads; new building work was suspended from 1943 and only essential repairs undertaken thereafter. Other considerations apart, it latterly required three permits for the material to put in a window and the same number of months to get the permits. The jump in B2 for 1942-43 reflects the large payments to our corps of emergent charcoal manufacturers that hot weather.

We needed and would have been allotted any sum we liked under B7a but roads are repaired not with rupee notes but by labour, and that, as I have said, remained chronically short. On occasion, one scrounged a bit of help from the many military units training in the reserves, particularly the engineers who constructed a few useful bridges, but the sum total of their wear and tear on our crumbling communications far exceeded anything done in return. Few divisions engaged in all-out war production were, I imagine, so heavily invested—and infested—by military formations. We had the I.M.A. cadets and the Gurkha regimental centres from the very outset and then a constant succession of ancillary shows—from jungle warfare schools to user-trial and other hush-hush establishments. Accommodating all these without unduly dislocating high-pressure production proved no easy task and staff cars became as common at one's halting camp as contractors; while the *basha* and the bren-gun pit multiplied in the forest like mushrooms. Considering the variety of units and numbers of men involved, and the nature of their training, one must acknowledge their good discipline and general appreciation of a *junglewala's* problems. Incidents in plenty there were—locks shot off with Tommy guns, motor gates removed bodily, the odd bungalow broken into, and so on—but the amount of permanent damage to our forest estate was surprisingly small. I except here, naturally, the Tactical Training centre which in April 1944 abruptly expropriated over 25 square miles of the finest and most centrally situated forest in the Doon and necessarily extended its "battle inoculation" courses to the tree crops among which its units trained; with, at times, repercussions—of a literal sort—beyond. For ricochets or "overs" from Sherman 75's and the like used to cause considerable alarm and despondency among forest workers in lots bordering the area, to our general discomfiture and the proliferation of correspondence. One A.P. shell took a whizzing plunge into a contractor's *chappar*, Suswa valley way, but found the inmates not-at-home. Another hit the base of a *sal* tree and tore vertically up the stem to a high lodgement near the crown. But in other respects we contrived fairly successfully to insulate the Prohibited area, as it was called, from the rest of the division by a "cordon sanitaire" of controlled strip burning and we took over only one of their fires. Twice, on their home ground, they nearly succeeded in blowing up the D.F.O. but as their G.S. II and III plus a perfectly good jeep would have kept me company, I bear no grudge.

What the jungle population thought of all this lethal soldiering I do not know. Outside the Kansrau Sanctuary, it is certain that they suffered severely; all, that is, except the Felidae. Even the elephants, regular hot weather visitors from over the Ganges, once or twice came in for a peppering and swam hastily back to the haven of Lansdowne division. The whole balance of hoof and claw must have been materially altered, for we undoubtedly got a reinforcement of tiger and panther chivvied over from the Saharanpur side, where the 39th Div. was doing its noisy stuff, while at the same time losing far fewer than usual of our own. Tigers are strictly rationed in the Doon, a practice ante-dating the war, and whereas thirteen were shot in 1939-40, the average dropped to five or six a year thereafter, largely, I think, because the war-invasion of their quiet native haunts made them particularly wary. Their comparative immunity, at any rate, could not be ascribed to any drop in the number of authorised *shikaries*. Throughout the war years, big game permit issues averaged sixty per season but it proved the triumph of hope over experience for the holders had singularly little luck. Meanwhile and especially after 1942, the deer were getting a bad time of it at other hands, as were game birds in the western Doon and fish (by bombing) everywhere. We did our best but conditions were all against us. Variety in the toll, and a sort of comic relief, was provided one season by a unit of Chins, who would eat birds

of prey, pine-martins, lizards and snakes with as much relish as the more orthodox *shikar* and whom I allowed to "make a murder" among the gruesome fruit-bat colonies of Sahaspur—and likewise of all the Rhesus monkeys within reach. I forgot to try them on white ants.

Well, that is most of the story and I really have no space for titbits, like our odd jungle chases after escaped P. O. W's.* or the incendiary burning of Karwapani rest house or how, in a now-or-never mood, we cocked a snook at Hitler and Hirohito by laying out some nice preservation plots and reserving numerous protected trees amid all the maelstrom of exploitation. It is time to draw up a brief balance sheet and have done.

When the tide of war receded, how did it leave the Doon forests? Depleted, certainly, of their finest trees— their biggest and best *sal* and *sain*, their *tun* and *bakli* and *gutel*; and with the Conversion circle badly out of gear, its P.B.I. exploited several coupes in advance, the finest of its P.B. VIII reverted (by *balli* fellings) to P.B.IX status and the garnered riches of its intermediate block all gone. But cleared, at the same time, of a tremendous lot of ancient lumber, including many a monopolistic old fig tree; remarkably little in arrears with cultural operations and in better shape for fire-protection and export than at any time in its history.

Came the day when I had to leave, booked like my wharf beams of yesteryear for Bombay and the open sea, neither of which I had set eyes on for more than a decade. It found me on crutches, for the Army had waylaid me at last, booby-trapping me on a "15 cwt." while out on an instructional excursion with the I.M.A. and there were bones broken. I had said good-bye to the faithful staff, including the two gallant old gentlemen (combined ages close on 120 years) who had come back to service to assist me and the Doon division through the last difficult seasons, and as I lay, an exceedingly tired man, on the lower berth of my compartment with the train gathering speed through the cool darkness of the Doon valley, I could not help feeling glad of the shrouding night that prevented a last look on the forests I had loved but had had to work so hard. And with that feeling, came another —that it was but fitting to be leaving them in an equally battered condition myself. For the rest, the words of the poet came to my mind—"I am a part of all that I have met. . . .”; some part of me, in turn, I realised, something precious of youth and vigour and professional zest was being left behind, for good and all, in the storied forests of the Doon.

A TREE PLANTATION PLAN FOR INDIA

(ii) Avenues for Town Roads

BY M. S. RANDHAWA

(Secretary, Imperial Council of Agricultural Research, New Delhi)

In India we have the largest number of flowering trees in the world, indigenous as well as exotic, which we can utilize for beautifying our towns. On account of the diversity of climate and soil, which we have, we can grow almost any tree from temperate Rhododendrons and double-flowering cherries to tropical Amherstias and Browneas. However, as compared with our opportunities, our achievements are puny. Barring a few cities like New Delhi, Lucknow and Bangalore, we have made little use of the tree material available in our country.

Roadside Avenues in Other Countries

Even in countries in the temperate zone, where modern western civilization has made comparatively greater progress, it is only recently that attention has been drawn to the use of trees for beautifying towns.. Barring France and Italy where Lombardy poplars are extensively grown we find little beauty in the town roads of Europe. With the intensive house building activity which followed World War I, people in England awakened to the necessity of planting their town roads

*One ranger who chased, fought and recaptured a German singlehanded earned the Viceroy's **commendation**.

with beautiful trees. The outer streets of Birmingham show careful planning with liberal use of trees and grass. In Liverpool grass is grown even between tram-lines with flanking hedges.

However, it is in American towns that we see planned vegetation at its best. The French immigrants introduced the Lombardy poplar in Canada, and it is commonly grown as a road-side tree in the cities of Quebec and Montreal. Maple, which is the national tree of Canada, as oak is that of Germany, is extensively grown as a roadside tree in Canada and eastern U.S.A. Of all the cities in the temperate regions, the city of Washington is perhaps the most aesthetically planted. The amber, yellow and coppery tints of maples, oaks and chestnuts in the Rock Creek harmonising with the yellow colour of buildings in the autumn months of October and November leave an indelible impression on one's mind. Japanese double-flowering cherries and peaches, dogwood trees with white and pink flowers and fragrant magnolias lend grace to the state buildings and monuments of this beautiful American city.

However, as compared with tropical and sub-tropical countries the tree material available to the inhabitants of temperate countries is comparatively prosaic. Trees with brilliant flowers and birds with gay plumage occur only in the tropics and sub-tropics. Temperate countries of Europe and America have hardly anything to match the blazing *Gul Mohar* (*Poinciana regia*) avenues of Kandy, brilliant blue *Jacaranda* avenues of Johannesburg and graceful palm avenues of North African towns.

Considerable attention has been paid to the lay-out of roadside avenues in Cairo. Along the long road leading from Gizeh to the Pyramids, we find a beautiful avenue of alternating *Gul Mohar* and *Eucalyptus*. *Jacarandas* are also planted extensively along roadsides, and also date-palms mixed with clipped box-like trees. Clumps of date-palms are grown in the back yards of houses. In Morocco, the French colonials have planned the roadside avenues of their towns in an artistic manner. In the main thoroughfare of Rabat, a dwarf variety of date-palm, is grown in the form of avenues with grass and beds of annuals at sides. Triangular plots in the town are planted with Persian Lilac, and *Schinus terebenthifolius* which bears red berries in profusion in the month of November. The compounds of private houses are enlivened by orange flowers of *Bignonia venusta*, magenta coloured Bougainvilleas, and bright-blue shrubs of *Plumbago capensis.*

Ordered Variety

The broad aims of town planning are that the towns must be made more efficient, more healthy and more beautiful. For making them healthy and beautiful we require not only spacious well-planned streets designed as a unit, but also well planned roads and parks with planned plantation of ornamental trees. What is desired is *order*, which is not the same thing as uniformity. Deadly uniformity with the same stamp placed on all the houses and trees in the whole town will be as undesirable as our present confusion with every one following his own sweet will and spreading ugliness. What is desired is ordered variety with not only houses in a street following a particular design but trees also planted and replaced from time to time according to a plan.

Road Plan and Plantation Plan

For our towns we are not only in need of 'Road Plan' for traffic but also 'Plantation Plans.' *For every town of importance a 'Plantation Plan' should be drawn and rigidly adhered to.* For new roads it is comparatively easy to plan plantation of unfamiliar flowering tree, and it is the old roads which present a problem. The wholesale cutting of existing trees will render them shadeless. Hence the only practical approach is *replacement of dead, decaying and old trees according to a plan*, and removal of young trees planted within 2-3 years. Once a plan is made, it should be rigidly followed not only in new plantations but also in replacements. Some imaginative person planned beautiful avenues of flowering trees for the Benares Hindu University, which have disappeared or have become patchy on account of the absence of a plantation plan, and lack of aesthetic taste in those who later on managed them. Every one cannot appreciate colour and beauty. While we call to our aid painters and artists for furnishing and decorating our houses, we should also take the help of aesthetically-developed arboriculturists. The arboriculturists should be selected from individuals who have an eye for colour and beauty, and they should also be given training in art schools in garden designing and theories of colour harmony and colour contrast. The artist should be introduced to the garden,

and the arboriculturist should be initiated into the mysteries of the art school. Both will be gainers from this experience. While the fresh breeze of the garden, and the glamour of Erythrinas, Colvilleas and *amaltas* (*Cassia fistula*) will invade the studio, freshening the minds of the artistes, the garden will also gain from the impact of imaginative and sensitive minds who will be able to convey their experience to the common man in the form of beautiful pictures. Thus the blaze of *Gul Mohars*, the glory of Colvilleas and the splendour of *kachnars* (*Bauhinia variegata*) will brighten our homes throughout the year, even when other flowers are dead and gone. On the other hand, we will be spared the pitiable spectacle of arboriculturists who plant *peepal* (*Ficus-religiosa*) and *sheesham* (*Dalbergia sissoo*) trees on our roads in the towns.

Choice of Trees

While shade and economic utility should be the criteria for selecting trees for national, provincial and district roads passing through the countryside, different types of trees are required for town roads. *For roadside avenues in towns and cities, shade and beauty are the sole criteria* which we should consider while selecting trees. Unfortunately there are very few trees which combine shade with beauty of flowers, for the large majority of our flowering trees are deciduous. Where space available is limited and only one row of trees can be grown on each side of the road, flowering trees like *Gul mohar, Amaltas, Jacaranda, Erythrina* and *Spathodea* may be grown alternating with shade trees like *Eugenia operculata*. Choice should be restricted to one species only for each street. Very tall trees like *Eucalyptus* and *Millingtonia*, and trees with spreading crowns like banyan are unsuitable for town roads, for they interfere with electric wires. Medium-sized trees like *Eugenia operculata*, and *Pakur* (*Ficus infectoria*) which are extensively grown in New Delhi are ideal for shade while for beauty we have a large number of trees to choose from.

Double Avenues for Cities

Double avenues of trees are a necessity in big cities, where wide roads are available. In an ideal road for a traffic centre of the metropolis provision should be made for fast moving traffic such as motor cars and lorries and slow moving traffic such as horse-drawn vehicles, bullock carts and bicycles. A road divided into four sections for slow and foot traffic on each side, separated by islands planted with grass and shrubs in the middle and flanked by footpaths for pedestrians should be our ideal. *We recommend double avenues of trees on outer sides of the footpaths; an outer row of shade trees and an inner row of ornamental flowering trees.* The outer row should be composed of evergreen shade trees with dense foliage, such as Tamarind (*imli*), *Polyalthia longifolia, Eugenia operculata, Purtanjiva Roxburghii, moulsari* (*Mimusops elengi*), *Ficus retusa, Neem* (*Azadirachta indica*), and *Pakur* (*Ficus infectoria.*) The function of the outer row is of shade only. These trees *should be planted in pure avenues and not in mixed patches.* Growth in pure avenues provides a beautiful skyline and a pleasing effect due to uniform size and shape of the crowns of the trees of the same species, while a mixture creates an ugly confusion with a jagged skyline. The inner rows should be planted with ornamental flowering trees only. The outer rows of shade trees will provide shade for pedestrians on the footpaths and at the same time will furnish a green background for the pink, red, crimson and yellow flowers of the flowering trees. The trees in both the rows should be planted at a distance of 30 feet from each other with the trees in opposite rows alternating.

Naming of Streets and Roads

In modern towns constructed in the form of blocks, numbering of streets is desirable, as it is the easiest guide for a newcomer. In old towns we usually find the roads and streets named after historical personages, officials, and lately after municipal commissioners who regard the naming of roads after them as the royal road to fame and immortality. The result has been encrusting of the road crossings with clumsy sign-boards, particularly when the seeker after cheap popularity insists upon retaining all customary titles. This involves waste of time and energy in correspondence and those who have to send telegrams should be justified in sending a bill to the immortality-hunting gentry who while perpetuating their own memory, cause so much inconvenience to others.

Bioaesthetic planning will also simplify the problem of naming roads and streets. The streets can be named after the flowering trees which are grown on the road, such as Amaltas Avenue, Kachnar Avenue, Gul Mohar

Avenue, Asoka Avenue, etc. Not only the roads will be readily recognizable, but this device will also enable the citizens to familiarize themselves with our common flowering trees. Some imaginative pioneer has actually named a road in Lucknow as Millingtonia Avenue after *Millingtonia hortensis.*

Triangular Islands

In every big town we find triangular pieces of land at the junctions of roads. To safeguard against traffic accidents these plots are not leased for building purposes. There are many such triangular plots in the Civil Lines of Allahabad. At present these are lying neglected covered with ugly self-grown jungle trees. How beautiful these can be, particularly the sunken ones, if they are planted with flowering trees. Only one species of trees should be planted in each triangle. Covered with Spathodeas, Lagerstoremias, Jacarandas and *Kachnars,* these triangular plots will appear very beautiful, serving as nodal points of beauty, affording welcome shade to pedestrians and refuge for young lovers.

Beautiful roads, well-planned parks and squares will bring the beauties of nature within the reach of the common man in our towns and cities. The dwellers of slums will also appreciate the beauty and splendour of flowering trees, at least their children will, who will have an opportunity of growing up in a new environment. Those who have lived in filthy surroundings for generations cannot be suddenly transformed in a few years into lovers of beauty. But the attempt is certainly worth making and results will be tangible after some time.

Some Colour Schemes

While most of the flowering trees look beautiful when planted in pure avenues, there are some species which flower at the same time and the colour of their flowers also harmonizes, and hence appear more effective when planted together. Some of the flowering trees which flower in the same season are grouped below in schemes with due regard to colour harmony and are recommended for planting along our town roads:

SCHEME NO. I.

Amaltas (Yellow)	*Gur Mohar* (Scarlet orange)	*Amaltas* (Yellow)

This is a very striking colour scheme, the rich yellow colour of *Amaltas* flowers contrasting with the scarlet orange colour of *gul mohar* blooms in the month of May when both the trees are flowering.

SCHEME NO. 2.

Peltophorum ferrugineum Rusty Shield Bearer (Golden yellow)	*Colvillea racemosa* Colvilles Glory (Orange red)	*Peltophorum ferrugineum* Rusty Shield Bear (Golden yellow.)

This colour scheme is very effective in October when both these trees are flowering and a colour effect similar to that in scheme No. 1 is produced.

SCHEME No. 3.

Jacaranda mimosaefolia (Blue)	*Grevillea robusta* (yellow)	*Jacaranda mimosaefolia* (Blue)

Both these trees flower in April together and a beautiful colour-effect is produced, which appears soothing in the glare of April sunshine.

SCHEME NO. 4.

Spathodea nilotica Fountain tree (Orange crimson)	*Erythrina indica* Scarlet Erythrina (Scarlet red)	*Spathodea nilotica* Fountain tree (Orange crimson)

Both these trees flower in March, when they are a blaze of colour.

SCHEME NO. 5.

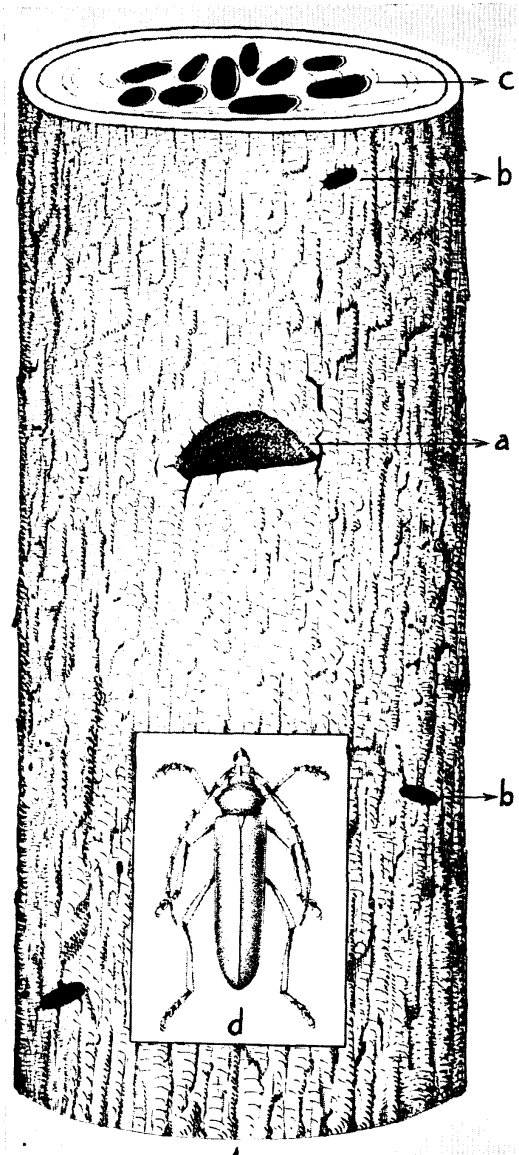
Cassia nodosa (Pink)	*Cassia marginata* (Pinkish red)	*Cassia nodosa* (Pink)

Both these trees flower in May and June when a very mellow colour scheme of pink and red colour is obtained.

SCHEME NO. 6.
Bauhinia Scheme.

Bauhinia variegata. (Purple-mauve Var.)	*B. variegata* (White Var.)	*B. Krugii* (Light magenta)	*B. variegata* (Light pink Var.)

This colour scheme which is composed of three varieties of *Bauhinia variegata,* pink, white and purple-mauve, and light magenta (*B. Krugii*) is recommended for dust-free roads of residential areas. All these Bauhinias blossom in a leafless condition from middle of February to middle of March when they look like huge boquets of pink, white, purple and light magenta flowers. This is a very pleasing colour scheme and is highly recommended.



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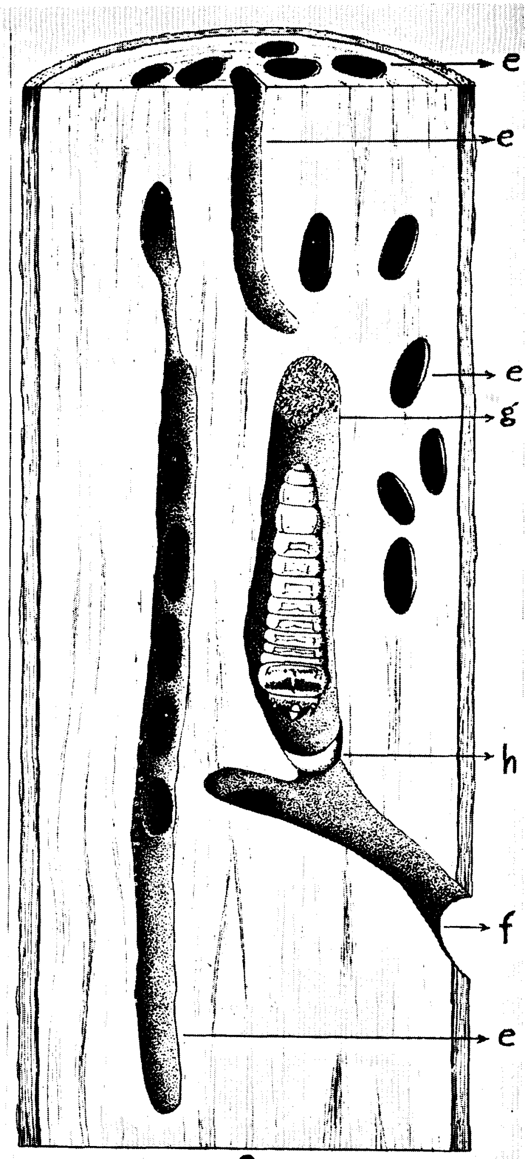

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Quercus incana stem showing crescent shaped exit hole (a), oval ejection hole (**b**), galleries in cross section (c), beetle inset (d).

Longitudinal section of attacked stem showing galleries (e), exit hole (f), pupal chamber with larva (g), chalk operculum (h).

List of ornamental trees suitable for Town roads.

No.	Foliage trees for outer Avenue		Flowering trees for inner Avenue
1.	*Averrhoa carambola* (*kamrak*)	..	*Cassia fistula* (*amaltas*)
2.	*Callistemon lanceolatum* (Bottle brush tree)	..	*Bauhinia purpurea* ; *B. variegata*
3.	*Anthocephalus cadamba*	..	*Colvillea racemosa*
4.	*Eugenia operculata*	..	*Peltophorum ferrugineum* (Rusty shield bearer)
5.	*Polyathia longifolia* (*ashoka*)	..	*Spathodea nilotica*
6.	*Putranjiva roxburghii* (*jia puta*)	..	*Jacaranda mimosaefolia*
7.	*Sterculia alata* (Australian Bottle-necked tree)	..	*Poinciana regia* (*gul mohur*)
8.	*Pitheclobium saman* (Rain tree)	..	*Lagerstroemia flos-reginae* and *L. thorelli*
9.	*Melia azadirach* (*neem*)	..	*Grevillea robusta*
10.	*Tamarindus indica* (*imli*)	..	*Gilircidia maculata.*

APHRODISIUM HARDWICKIANUM WHITE (A BORER OF QUERCUS INCANA) AND ITS CONTROL

BY A. H. KHAN AND B. M. BHATIA

(*Branch of Forest Entomology, Forest Research Institute, Dehra Dun.*)

Introduction. A preliminary investigation into the insect pests of *Quercus incana* in Dharamsala range, Kangra forest division, Punjab, was carried out in May-June 1945 on the request of the Punjab forest department. It was found that in the *Q. incana* areas at Dhalun (elevation 3,500 ft.) the most serious pest was the Cerambycid borer *Aphrodisium hardwickianum*, and as a result of the observations then made experiments on the control of the borer were arranged in collaboration with the divisional forest officer. These experiments were examined in September, 1945, and the results, which have been found to be satisfactory, are given in the following note together with an account of the habits of the borer on which the method of control is based.

Damage by the Borer

Practically every tree in the oak area at Dhalun had been attacked either recently or in past years. A tree may look quite sound to all outward appearance, but on splitting it is seen that a great proportion of the wood has been removed by the tunnelling of the larvae. The annual incidence of the borer is relatively low, but the accumulation of damage of several years renders the trees useless for any purpose except fuel, the quantity of which is materially reduced.

Habits of the Borer

The beetle is metallic green in colour and $1\frac{1}{5}$ to $1\frac{3}{4}$ inches long. (*Plate 18, fig. 1d*). The attack starts with the egg laying of the beetle during the monsoon; the actual oviposition of the beetle has not been observed but it appears from the examination of attacked trees that the eggs are laid in the crown, side branches and upper portion of the stem. The larva on hatching bores into the wood along the branch towards the stem where the simple tunnels excavated at the early stages become more complicated and extensive as the larva develops and progresses downwards along the stem. Both the sapwood and heartwood are affected. The wood dust excavated by the larva is ejected through round or oval holes (*plate* 18, *fig.* 1*b*) made through the bark at intervals. The larva when full fed tunnels obliquely outwards and after making a neat crescent shaped hole (1 in. x $\frac{1}{2}$ in.) (*plate* 18,

fig. 1*a*) through the bark returns to the wood for pupation (*plate* 18, *fig.* 2*g*). The crescent shaped hole made by the larva is eventually used by the beetle for emergence which takes place during the monsoon. The life cycle of the beetle appears to be annual. At the time of inspection in May-June (28-5-45 and 3-6-45) practically all the larvae in the stem had prepared the crescent shaped holes and were found in the pupal chambers which are prepared by the larvae at an angle from the sloping tunnel leading towards the crescent shaped exit hole. The mouth of the pupal chamber is sealed by a dome shaped chalk operculum (*plate* 18, *fig.* 2*h*) before pupation.

Experiments on Control Measures

The fact that the larva makes a conspicuous crescent shaped hole through the bark before pupation, and that practically all larvae in attacked stems had prepared these holes by the first week of June and were found in the pupal chambers, indicated a weak point (which was used for its control) in the life history of the pest. It was evident that the beetles on maturity must normally emerge through the tunnel leading towards the crescent shaped exit hole. In order to kill the larva at this stage or to stop the emergence of the beetle resulting from it, the following methods were tried in the oak area at Dhalun.

(*i*) On 3rd June, 1945, 42 crescent shaped holes on 28 trees (ranging from one to three per tree) were plugged with a rag soaked in coal tar and pushed through the hole with a twig as deep into the tunnel as possible.

(*ii*) On the same date as in above, 10 holes on 8 trees were blocked with stones hammered tightly into the holes.

Results of the experiments. The treated trees were felled and examined in September 1945. The results are that both the treatment were 100 per cent successful in stopping the emergence of beetles which would have otherwise gone out to start a new infestation. In treatment (*i*) the beetles were found dead or dying in or at the mouth of the pupal chambers, and in (*ii*) the stone blocks proved an effective barrier against the emergence of the beetle. Beetles were not able to make alternative exit tunnels.

Procedure for application of the treatment. The treatment described above should be applied from the 1st of June to the 15th June annually and should cover all affected areas in a locality. Patrol the area thoroughly to detect and treat the new crescent shaped holes by plugging with coal tar. Blocking with stones although effective, will probably be objected to because of possible subsequent damage to saws and axes. The new crescent shaped holes can be easily detected by their neat clear-cut appearance and are further evidenced by a pile of freshly ejected frass on the ground directly below the hole. They are distinct from old holes which are wholly or partially occluded. They are also distinct from the ejection holes made by the larva earlier along the stem at intervals, which are smaller in size and round or oval in shape.

It should be practicable to apply the treatment on large-scale for the following reasons:—

(*i*) Only one operation in a year from 1st June to the 15th June is necessary.

(*ii*) The holes to be treated in a stem are mostly accessible, usually within six feet of the ground level.

(*iii*) The percentage of trees showing treatable (crescent shaped) holes were found to be relatively low at Dhalun in 1945; not more than 10 per cent of the trees were found with these holes.

(*iv*) The expense and labour involved in the treatment is negligible.

Remarks

The method aims at the reduction of the borer population in the area, and if the treatment is adopted as a regular annual operation the incidence of the pest is expected to decrease progressively. In order to achieve satisfactory results concerted action is necessary to apply the treatment in the affected area as a whole. The Punjab forest department have decided to try the method on a large scale in the affected oak areas in Dharamsala range including the neighbouring private forests.

This Borer is also recorded as a serious pest of *Q. incana* at Sitoli 5,000 ft., West Almora division in the United Provinces. The beetle has also been recorded from Bhim Tal 4,500 ft., Naini Tal division, U.P. and from Nepal but we have no attack records from these places. No alternative host of the borer has so far been recorded. The forest entomologist will be glad to have further information on the incidence of the borer and any comments on the method of control described above.

Acknowledgments are due to Mr. J. C. M. Gardner, Forest Entomologist, for his valuable suggestions in preparing this note.

THE PROBLEM OF DENUDED LAND IN BIHAR

By J. N. Sinha

(*Divisional Forest Officer, Dhalbhum Forest Division, Bihar*).

"Look," I said to our distinguished American guest touring India on soil erosion problem, "look, what dismal expanse of desolate waste cruelly greets the hungry and helpless eyes of men and cattle. Is this not a colossal yet avoidable national loss calling for immediate attention?".

I had put this to the American scientist several times before in course of the trip, but he had kept the answer to himself. The subject was however so agitating my breast that I was anxious to force the issue.

The scene lay within the Damodar watershed in the district of Manbhum. Ahead and about us stretched miles and miles of good earth lying desperately fallow with but dashes and dots of cultivation occurring shyly in the troughs of those dry undulations. The country-side was deeply sheet eroded and the jaws of gully erosion had begun their attack and had in places registered considerable progress. It looked hardly green even in the middle of this rainy season. Skeletons of stunted cattle looked piteously towards us. As we motored through this dumb helpless expanse the country-side seemed to roll itself up and rush towards us like oppressed and neglected people with petitions against grievous wrong.

The soil conservation scientist had held himself off perhaps too long. "Why" he asked in apparent impatience, "why do you call all this land waste? If it feeds so many live stock, is it a waste? Is a ton of fodder per acre of no value?"

This unfortunately is the common error. The foreign scientist's good argument sat awry on the given premises. "I would agree hundred per cent." I replied, "if it did feed the cattle. But does it? Unfortunately you are seeing the land when it is at its best and you find a few points of green grass. But if you had seen it after the rains or during summer you would find it a bleak and brown despair rather than pasture. If cattle had to be fed on fodder and not on sentiment then I can tell you authoritatively that they most certainly are not fed."

"Perhaps I have been misunderstood" I added, "perhaps my profession of forestry has lent itself to that misunderstanding. I do not say, convert all the land into forest. No. All that I say is, utilise the land for the best purpose. Part of it can be turned over to agriculture, part to pasture. The rest which you cannot use otherwise put that to forest.

The scientist suggested that wherever he went he found himself baulked by the baffling problem of too many cattle. "Unless you reduce the number of cattle" he said, "the situation is difficult to remedy."

I told him that that undoubtedly was one of the problems but suggested that in my opinion reduction in the number of cattle alone would achieve very little. "Cut down the number to half," I said, " but leave the land as now, and you will find the cattle still half fed. The basic work to be done is to create real pasture land. For that, irrigation facilities are needed. Pasture land has to be properly maintained and irrigated and rotational grazing must be enforced. That is to say, divide the grazing land into two blocks and graze them in alternate years so as to give the required rest to grass."

I told our visitor that if the number of cattle must be reduced that could be achieved if certain preliminary conditions were satisfied. First, we have to undertake to supply the agriculturist with sufficient manure at reasonable cost and facility, for he has to keep many head of cattle merely for production of cow-dung manure. The average land in Chotanagpur will grow very little without sufficient manuring. Given the required fertiliser and the "manure" cattle will automatically be eliminated. Next we must create fuel reserves for groups of villages in the denuded regions, for the cow-dung is at present used as fuel. If sufficient firewood will be available nobody will maintain the surplus cattle. Thirdly, as a measure of benevolent compulsion, we can introduce a tax of say one rupee per head of cattle per annum, the proceeds of this tax being strictly earmarked for benefits of the people concerned. These three measures will in two or three years automatically reduce the number of cattle to the minimum needed for ploughing and milk.

The murderous flood in western Bengal caused by the Damodar river, whose critical catchment lies in Bihar, has brought the problem of denuded land to the forefront. I understand a far-reaching scheme for controlling Damodar floods has been provisionally prepared by the joint labours of the governments of India, Bihar and Bengal. I have not been able to get to know the details first hand, but quote, with permission, the following extract from a letter of Mr. L. R. Sabharwal, I.F.S., Conservator of Forests, Bihar, who has actively participated in the formulation of the said scheme:—

"Afforestation and anti-erosion measures have been given very high place in the scheme. While the experts differed in other methods, such as the type and location of dams and many other engineering problems, it was the unanimous opinion of the Damodar flood control committee that it was absolutely indispensable that the upper catchment area must be brought under scientific management which will include not only regulations of felling, grazing and cultivation but also afforestation and construction of small earthen *bundhs*, plugging of gullies and various other anti-erosion measures, such as contour-ridging and *bundhing*. It was, I believe, first time that the forest department was represented on a committee of this nature in India and I can assure you that the views of this department on the subject of the part which vegetation plays in holding up run-off etc. were fully and completely accepted not only by the committee but also by the governments of India, Bengal and Bihar.... The committee deserves great credit and praise for the way it has dealt with the problem in hand."

So far this is very hopeful. Every one who has the problem at heart will feel encouraged. But, for the moment, I choose to remain the harmless sceptic. My eyes cannot yet see that blissful day which is said to have dawned on the problem of denuded land. Without meaning the slightest disrespect to anybody I will condense my feelings in the followig quotation from a school book:—

"I can call the spirits of the Deep" said the mystic."

"Yes," replied the sceptic, "but will they come?"

If I were to do the job I would first of all extensively and intensively contour-trench and contour-terrace the entire watershed. I would build thousands of small dams in suitable places all over. I would also build a few big dams in the hills which will hold up large volumes of rain water and help to irrigate thousands of acres of land below. An instance in view is the Dimna dam built by Messrs. Tata Iron & Steel Co. Ltd. in the Dalma hill region near Jamshedpur. This dam has been built by the Company for supply of water to the steel works and to the town of Jamshedpur, but it gives the idea and will serve equally well for flood and soil-erosion control. In the forest areas there are scores of fine sites where large masonry dams can be suitably and very profitably built. The dams can and should all be multi-purpose dams, namely, soil-erosion control, irrigation and hydro-electricity. The cheap electricity can be employed for lift irrigation where the dam water will not reach. And what wealth and prosperity cannot be produced through that plentiful irrigation water and that cheap electricity?

The thousands of small earth dams all over the watershed and the contour trenches or ridges will achieve the following indispensable preliminaries to the building of large masonry dams. They will—

(1) hold up a large proportion of the rain water and prevent its immediate rush off to the river;

(2) compel an appreciable quantity of the rain water to sink into the sub-soil, later to emerge in the shape of beneficial springs;

(3) will check the rush of water careering down the slopes and break its destructive momentum. The eroding power of water varies as the square of its velocity. So by checking its rush soil erosion will be greatly reduced and ultimately eliminated.

I have contour-trenched a barren hillock near Jamshedpur and another near Ghatsila. I claim that very little water of normal rainfall escapes from the hillocks. It is all caught up in the trenches and gets forced into the sub-soil. The little that escapes is free from silt. It is unanimously agreed by all who have seen the hillocks and was particularly stressed by our distinguished visitor that it is work like this that is wanted all over the watersheds of our problem rivers.

The urgent and immediate need is to carry out an intensive land-use survey over the entire watershed. It can then be decided

which part of the existing waste land should be turned over to agriculture, which to pasture and which to forest. Having made the decision an army of men equipped with tools should at once be put on the job. All the money required should be found, if need be by borrowing, for it will all be handsomely repaid. The right person should be given the work and he should have a free hand, untrammelled by petty formalities, to complete the job rapidly.

The hillock near Jamshedpur which I have contour-trenched and reforested and closed to grazing by means of trenches six feet wide and four feet deep all round was visited. It has responded remarkably to the treatment within two years. While an untreated part of the same hillock is brown and bare, the treated part is flourishing with luscious fodder grass waving gaily and forest plants making devotional rings around. What was a dismal denuded stony hillock on the way to gully erosion has been, by a simple method and at a comparatively small cost, converted into the beginnings of a good forest. Is it not a crying national need to utilise such barren waste lands which otherwise are dead loss economically but when reforested add to the national wealth? In addition it is measures like this that alone will remedy flood havoc in the plains and will prevent the colossal erosion of productive top soil that is taking place unchecked, if not at an accelerated rate, in all the hilly and undulating regions of the province?

The profuse growth of fine grass waist high in the closed area was particularly remarkable and I pointed this out. "Yes" replied our scientist, "closure is all right but how are you going to feed the teeming cattle if you close half of the available pasture against them? Even the whole is insufficient to feed them, how will only half be enough?"

I replied, "The quantity of grass growing in this fenced-in area is more than the quantity found in even ten times the area of abandoned wastes that you see around. So half of the available land when treated will feed many more cattle than the entire area is at present able to."

Miles and miles of waste lands occur in all the five districts of Chotanagpur. In Santal Parganas, parts of Monghyr and Gaya and in the southern Rohtas hill region of Shahabad a similar situation exists. It breaks the heart to see these waste lands. Is it not a sorry tale that so much land should exist unused and still men and cattle should go hungry? And yet the problem is not hopeless, not even as difficult as it is imagined. In Dhalbhum forest division I have taken up such barren eroded land and already grown flourishing bamboo forest. The bamboo plantation of 1939-40 already contains clumps with 20-25 culms and is ready for exploitation. *Sabai* (*Eulaliopis binata*) which is so much in demand in that area, is also growing very well. *Piasal* (*Pterocarpus marsupium*) and *gamhar* (*Gmelina arborea*) are being easily grown by ploughing up the land and broadcasting the seeds mixed with *boga* (*Boga medeloa*). The land here is fairly level or gently rolling. The plantations are all fenced in by trench six feet wide and four feet deep with the dug up earth making a *bundh* inside. By the way, it has been the experience that no plantation is worthwhile in the long run without fencing, and the trench-fencing introduced by me in Dhalbhum appears to be the cheapest, the most effective and enduring. On the *bandh* *sissoo* (*Dalbergia sissoo*) and *sabai* are growing promisingly enough to repay the cost. Inside the fenced area the land not yet taken up for plantation has been temporarily given to the villagers and they are growing food crop. The fencing has improved the land and the villagers in return do weeding of *sabai*, etc., free of cost. In the plantation grass grows profusely (while the land immediately outside keeps bare and useless) and the villagers are allowed to cut the grass and feed their cattle. It has been such a boon to them,

TRACTOCOPEVODIA—A NEW GENUS OF RUTACEAE

By M. B. Raizada, M.Sc.

(*Assistant Forest Botanist, F.R.I., Dehra Dun*).

Tractocopevodia Raizada et Narayanaswami genus novum (Rutacearum—Zanthoxylearum). Arbores parvae vel frutices magni. Folia opposita, unifoliolata, late elliptica. Flores in brevibus, paniculis axilaribus, dispositi; bractae bracteolae minutae. Calycis lobi 4, valvati, ovati. Petala 4 ovata, imbricata, reflexa, persistentia. Stamina 4, calycis lobis opposita; filamenta ad basin lata, subulata, ex disci parte inferiore emergentia; antherae latae, oblongo-ovatae, obtusae, biloculares, dorsi-fixae. Discus plus minusve

8-lobatus. Ovarium hirsutum, 4-loculare, 4-lobatum, haud profunde disco insidens. Ovula 2 in quoquo loculo, collateralia; stylus supra connatus, infra solutus, brevissimus, paene terminalis; stigma capitatum, 4-lobatum. Fructus 4 cocci; cocci coriacei, 2 valvati, ventraliter dehiscentes; endocarpium partim solutum.

Species ad huc unica.

Tractocopevodia burmahica Raizada et Narayanaswami sp. nov.

Arbor parva vel frutex magnus. Rami, germinium apices, et folia juvenia pilis densis, brevibus, luteo-bruneis, saepe subnigris brunescentibus ramorum inferioribus partibus. Cortex dilute luteus, longitudinaliter rugosus vel caniculatus sulcis irregularibus minutisque. Folia unifoliolata, late elliptica, rare ovata, 18-27 cm. longa; lamina 15-20 cm. longa, 8.5-11.5 cm. lata, apice acuta vel breviter acuminata, basi angusta vel rotundata; petiolus 3-5.5 cm. longus, teres, pulvinatus infra laminam, ubique breviter pubescens; lamina supra viridis subniger, dilute viridis inferne; nervi laterales 13-16; costa et nervi laterales superne impressi, inferne valde prominentes; nervus intramarginalis distinctus; superne costae inferior pars sparsis pilis fasciculatis; inferne costa et nervi laterales brevibus pilis fasciculatis.

Inflorescentia brevis pancula brunea, axillaris; rhachis principlis 3-5 cm. longa; rhachis et rami angulariter striati. Fores albi, fasciculis et embellis, fasciculati ramorum terminalium, lateralium apicibus, dispositi, bracteati, bracteolati, bractae minutae, 1 mm. longae, ovato-acutae, dense brunneo-pubescentes; bracteolae bracteis valde breviores, ovato-acutae, pubescentes. Flores 5-8 fasciculati; pedicelli 4-5 mm. longi; gemmae 2-3 mm. longi. Calyx 4-partitus; lobi valvati, ovati, 1.5 mm. longi, interne glabri, externe bruneo-pubescentes. Petala 4, ovata, ad apicem imbricata, obtusa, sinu longitudinale a basi ad apicem, externe pubescentia, 2.5 mm. long, 1.25 mm. lata, patentia, persistentia et reflexa, Stamina 4, calycis lobis opposita, 2.5 mm. longa; filamenta basi lata, subulata, disci basi emergentia; antherae latae, oblongo-ovatae, obtusae, biloculares, dorsifixae, Discus plus minusve 8-lobatus. Ovarium hirsutum, 4-loculare, 4-lobatum, haud profunde disco-insidens; ovula 2 quoquo loculo collateralia; stylus supra connatus, infra liber, sub-terminalis, brevissimus. Stigma capitatum, nigrum, 4-lobatum. Fructus 4 cocci; 4.5-6 mm. longi, 3-4 mm. lati, flavi, reticulate nervati, coriacei, 2-valvati, interne dehiscentes; endocarpium partim solutum, nitens; semina oblonga, solitaria (*vide plate* 19).

We append a description in English.

Tractocopevodia Raizada et Narayanaswami genus novum.

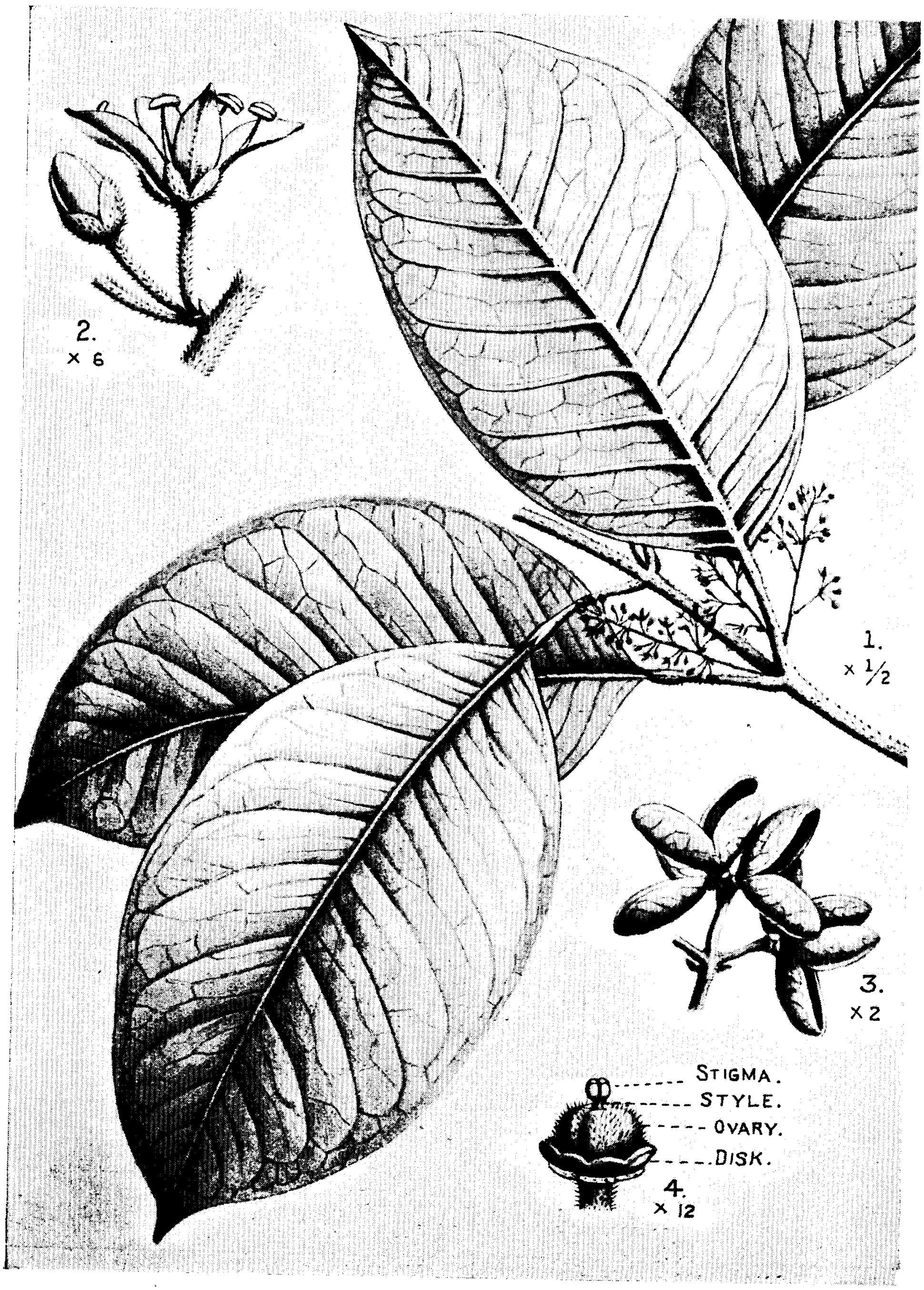
Small tree or a large shrub. Leaves opposite, unifoliolate, broadly elliptic, rarely ovate. Flowers in short axillary panicles, bracts and bracteoles minute. Calyx 4-partite, lobes valvate, ovate. Petals 4 ovate, imbricate, persistent and reflexed. Stamens 4 opposite the calyx-lobes; filaments broad at the base, subulate, arising from beneath the disk; anthers broad, oblong-ovate, obtuse, 2-celled, dorsi-fixed. Disk more or less 8-lobed. Ovary hirsute, 4-celled, 4-lobed *not* deeply sunk in the disk; ovules 2 in each cell, collateral; style connate above, free below, sub-terminal, very short; stigma capitate, 4-lobed. Fruit of 4 cocci, coriaceous, 2-valved, opening ventrally, 1-seeded; endocarp shining, only separating partially.

Genus monospecific so far.

Tractocopevodia burmahica Raizada et Narayanaswami sp. nov.

A small tree or a large shrub. Branches, tips of young shoots and young leaves covered with snuff-brown short dense hairs, sometimes turning to chocolate-brown, lower down the branch. Bark pale-yellow, longitudinally ridged and furrowed with minute irregular fissures. Leaves unifoliolate, broadly elliptic, rarely ovate, 18-27 cm. long; blade 15-20 cm. long, 8.5-11.5 cm. broad, acute or shortly acuminate at the tip narrow or rounded at the base; petiole 3-5.5 cm. long, terete, pulvinate below the blade, sparsely short tufted hairy all round; leaf blade plumbago-blue above, lurid beneath; lateral nerves 13-16 pairs, midrib and lateral nerves impressed above, prominent and much raised below, lateral nerves anastomosing near the margin to form a continuous distinct intra-marginal vein, lower portion of the midrib above with a few dirty brown tufted hairs, midrib and lateral nerves beneath with numerous short tufted hairs. Scattered

Inflorescence, a short axillary brownish-hairy panicle, main rhachis, 3-5 cm. long, lateral branches more or less horizontal, 3-8 mm. long,



Tractocopevodia burmahica Raizada et Narayanaswami

rhachis and branches angular and longitudinally striated. Flowers white, in fascicles or umbels at the tips of lateral and terminal branchlets of the panicle, bracteate and bracteolate; bracts minute 1 mm. long, ovate, acute, densely brownish-hairy, bracteoles, much shorter than bracts, similarly shaped and hairy; flowers 5-8, in each fascicle; pedicels 4-5 mm. long ; buds 2-3 mm. long. Calyx 4-partite, lobes valvate, ovate, 1.5 mm. long, glabrous on the ventral surface, brown hairy dorsally. Petals 4, ovate, imbricate near the apex, tip inflexed, blunt, with a ventral longitudinal fold running from the base to the top, hairy dorsally in the median line, 2.5 mm. long, 1.25 mm. broad, spreading, persistent and reflexed. Stamens 4 opposite the calyx-lobes, 2.5 mm. long, filaments broad at the base, subulate rising from beneath the disk, anthers broad, oblong-ovate, obtuse, 2-celled, dorsi-fixed. Disk more or less 8-lobed. Ovary hirsute, 4-celled, 4-lobed, but not deeply sunk in the disk; ovules 2 in each cell; collateral, style connate above, free below, sub-termina, very short; stigma capitate, black, 4-lobed. Fruit of 4 cocci, each 5-6 mm. long, 3-4 mm. broad, yellow, finely hairy above and reticulately veined, coriaceous, 2-valved, opening ventrally, 1-seeded, with the second very minute; endocarp shining, separating only partially. Seed oblong (immature), not shining.

Pyehpat, Myitkyina dist., Burma, 6,200 feet, 25-4-1929, Sukoe 9145 (Holotype in Herbarium Dehra Dun), Hkamkawa near Htawgaw, Myitkyina dist., Burma, 4,000 ft., 20-5-1929, Sukoe 9971 (Holotype for fruit).

Flowering in the month of April and fruiting in May.

This very interseting genus has affinities with *Melicope* Forst. and *Tetractomia* Hk. f. on the one hand and with *Evodia* Forst. on the other. It approaches *Evodia* in having tetramerous floral parts, but differs from it in the 2-valved cocci, in the endocarp of the fruit only partially splitting and in general appearance. It also closely resembles *Tetractomia* in inflorescence and in the persistent reflexed petals but differs from it in the ovary being only partially sunk in the disk and with neither the 4 projecting lobes nor being deeply lobed.

It approaches *Melicope* in the deeply 4-lobed, 4-celled ovary and 8-lobed disk but differs from it mainly in having only four stamens and in the ovary partially sunk (not deeply) in the disk and in general appearance.

The styles are 4, very short, sub-terminal, free below, connate above. It more or less combines the salient characters of all these three genera and has therefore received a generic name, meaning a mixture of three.

EXPEDITING WORKING PLANS FOR FOREST CO-OPERATIVE SOCIETIES*

BY CH. HARI SINGH, P.F.S.

Introduction.—Working plans for forest societies are of importance not only from the point of view of effective control, but for the guidance of the members in their main task of management. A society without a working plan is like a drifter unaware of the direction in which to steer. The formation of societies in recent years has proceeded so fast that the organization of working plans has lagged far behind. The time lag between the organization of a society and its working plan not only taxes the patience of those members who may be imbued with the spirit of advancement, but offers opportunity to those in opposition to undermine the very existence of the society by indulging in nefarious propaganda. Instances are not uncommon in Kangra where such delays have resulted in failures of societies. It is, therefore, imperative both in the interest of the movement of forest societies and their efficient working that this time lag be reduced to the absolute minimum and efforts be made for the working plan organization to keep pace with the formation of societies.

Means to be adopted to expedite working plans

Closely analysed the problem of expediting working plans lends itself to practical solution if the following contributory factors are

* Paper presented at a conference of soil conservation officers in the Punjab, held at Hoshiarpur on November 19th to 21st, 1945.

ordinated. All these factors are interdependent and laxity in any one is likely to react adversely on the others. Briefly speaking the working plan organization resolves itself into the following main sub-heads:—

(*i*) Permanent maintenance of the essential working plan staff.

(*ii*) Creation of a healthy background by the co-operative department for the working plan officer.

(*iii*) Standardisation of working plans for the different types of societies in each division.

(*iv*) Timely publication of notifications by government to give effect to closures with effect from the date the working plans come into force.

Maintenance of permanent working plan staff

According to the accepted principle the preparation of a working plan is primarily the responsibility of a gazetted officer. This is particularly essential where a high degree of technical skill is needed or where villagers are to be associated in a managing capacity in respect of the management of the entire village forest estate which includes government forests. Such conditions particularly obtain in Kangra. But in forest divisions where simple closures of of private waste meet the object of management, there is no reason why the services of senior forest rangers with good experience should not be utilized. This will enable the forest department to tide over the difficulty of chronic shotage of gazetted staff.

The strength of the working plan officers required in each division will depend solely on the amount of work involved and the number of working plans or revisions each officer can turn out annually under a given set of conditions. But in either case a working plan officer must be provided with the following indispensable staff:—

(*i*) *Patwaris* to demarcate the land to be brought under management.

(*ii*) A demarcation *darogha* wherever required to assist the *patwaris*.

(*iii*) A draftsman.

The main reason for holding up the progress of working plans in Kangra is the time taken in demarcating government forests and private wastes, coupled with the limited number of *patwaris* lent for short terms by the civil authorities and their frequent transfers. The later difficulty has recently been surmounted by training *patwaris* departmentally. But to hasten the demarcation the full strength of the *patwaris* required for each working plan must be maintained. Owing to the shortage of *patwaris* no working plan officer in Kangra has been able to turn out more than four working plans annually each embracing an area of 436 acres on an average. This low outturn was also occasioned by the complicated nature of the forest and land revenue settlements which necessitated a detailed study of the revenue records of each village.

But such conditions I presume do not prevail in other divisions. Experience has shown that one *patwari* can conveniently demarcate 1,000 acres a month. Therefore, for working plans embracing less than 1,000 acres only one *patwari* should be detailed and for bigger villages the number of *patwaris* should be increased in the same ratio, allotting definite areas to each to fix the responsibility of correct measurement. Simultaneously the working plan officer should proceed with the writing up of the description of each compartment and other field and office work so that by the time the demarcation is complete he should be ready with the draft of the working plan. Before the actual demarcation is undertaken, a good deal of time is taken in deciding closures with the villagers, consulting revenue records and the preparation of tracings from the revenue *shajras*. This suggests the possibility of a working plan officer taking 2-3 working plans at a time so that while papers are being completed in one plan preliminary records will be prepared in another and major operations of demarcation, etc., will be in progress in the third. With this procedure it would not be difficult to turn out 2-3 working plans a month for one working plan officer. This has actually been demonstrated in October 1945, when two working plans were prepared by a forest ranger in one month for five different villages covering 808 acres with the help of four *patwaris*. In assigning different working plans simultaneously to one and the same working plan officer care should be taken to allot villages which are situated within an easy radius of reach to facilitate control and to avoid frequent shifts from place to place.

Before taking up the question of working plans it is very essential that the unit of management in each division be decided. Ordinarily it will be a compact village as no two villages are likely to be governed by one managing society.

But this does not preclude the possibility of prescribing the management of more than one society in a single working plan provided they are contiguous. This is actually being done in Kangra to avoid the necessity of a separate plan for each village and in the above quoted instance only two working plans were prepared for five villages having three different societies. The procedure will be a great short cut to the progress of working plans, but in its wake it will involve a strenuous effort on the part of the co-operative department to organise societies in contiguous villages at one and the same time.

The necessity of one demarcation *darogha* for each working plan officer is greatly felt in Kangra owing to the complicated nature of demarcation, but can be dispensed with if he is an unnecessary encumbrance in other divisions.

For the preparation of management and stock maps a draftsman is indispensable. The enlargement or reduction of maps to or from a given revenue scale to the required scale of management, if left to the working plan officer, will consume a lot of his time and will retard progress. A common draftsman for two or more working plan officers will leave a free hand for the working plan officers to deal with the field work and writing part of the working plans and will further reduce the cost of a working plan. But when a draftsman is employed he must be kept fully engaged by maintaining the full strength of working plan staff.

Creation of a healthy background by the Co-operative Department

The organization of a society is primarily the responsibility of the co-operative department. When fully explained the villagers in the majority of cases readily feel attracted by the benefits that accrue from the proper management of their land and give their consent for the formation of a society. In Kangra a society is taken to be organized and ready for a working plan when at least 75 per cent. of the right-holders accord their consent. The co-operative department after securing this consent feel satisfied that they have done their job. But the real difficulty comes in when the working plan officer makes his appearance to formulate his proposals of closures. Anyone conversant with the psychology of a villager knows that any restrictions imposed on the free movement of his cattle are invariably resented. Where, however, persistent propaganda succeeds in moulding his view, his inherent love of bargaining always prevents him from agreeing to closures to an extent which will restore a proper balance to enable his animals to live in harmony with their environments. Whereas the working plan officer is guided by the actual requirements of each area, the villager will always insist on parting with as little as possible. To bring about a compromise takes days, sometimes weeks, and weeks often pass into months. Failure to bring about a compromise sometimes results in postponement of the working plan. Instances of Trippal, Dorang and Ladori in Kangra may be cited where working plans had to be suspended for years in spite of the best efforts of the working plan officers. The alternative application of Chos Act may be advocated to such villages, but to my mind the lack of adequate propaganda and timely handling of the situation are mainly responsible for such failures. It is, therefore, suggested that before a society is offered for a working plan the opinion of the villagers should be educated by the members of the co-operative and forest departments so that no time may be wasted when the question of closure is taken up. Where, however, a difference of opinion may take place between the working plan officer and the villagers, the co-operative staff must act promptly as an intermediary to bring about an amicable settlement. In all cases the subordinate co-operative staff as well as the assistant registrar and the divisional forest officer must be present in the first general meeting of the society in which closures are to be decided before taking up the demarcation. Once the question of closure is settled, half the task of the working plan officer is over and the time taken by him in completing the working plan will depend on the staff available for demarcation.

Standardisation of working plans for different types of forests

Each forest division has its own soil conservation problems which within particular zones are bound to be very similar. Therefore, in practice the prescriptions of working plans within such zones will be very much alike. It will facilitate drafting of plans if standard skeleton working plans are prepared for each set of zonal societies under standard headings leaving blanks to be filled in by the working

plan officer. This will hasten drafting and obviate the necessity of typing in office. In Kangra in one and the same village as many as four different types of forests may occur. This, however, does not preclude the possibility of standardising plans for different types of vegetation to enable the working plan officer to adopt definite prescriptions for each type of forests covered by his plans. A good many working plans have been prepared in Kangra covering all types of forests and the latest are being adopted by the working plan officer to suit their requirements.

All working plans must avoid unnecessary phraseology and repetition and should aim at being brief, if possible confined to schedules of compartments and prescriptions and a year by year allocation of the one to the other, in fact an annual plan of operations for every year of the working plan period.

Timely publication of notifications

The speeding up of working plans is of little avail without the timely publication of the necessary closure notifications. A working plan normally should come into force from the beginning of a financial year. In order to synchronize the date of publication with the date of the enforcement of working plan, the closure notification should be submitted at least six months ahead. If this is not possible, the working plan will have to be postponed till another year as the government notification issued after the date of enforcement of a working plan cannot have retrospective effect. A registered society can execute the prescriptions of closures only if it is well armed with legal powers to enforce them. In the absence of such notifications the members are likely to get involved in legal difficulties. To speed up the publication of notifications, the working plan officers should submit the draft notifications during the course of the compilation of working plans as they generally take months to reach government through the usual devious channels. Cases are, however, not uncommon where such notifications have been delayed for over a year. Such delays vitiate the prescriptions, apart from giving opportunity to the opposition to undermine protection. Government should, therefore, be approached to expedite the publication of such notifications.

Before I close I would like to emphasise that in view of the great strides made by the soil conservation movement in the Punjab in recent years and the consequent increase in the number of forest societies, the required strength of the working plan staff should be settled for each division and the conference should ask for this staff to be sanctioned by government as quickly as possible. Once this staff is sanctioned and posted to a particular division, frequent transfers should be avoided to ensure continuity of work. In passing a word to the co-operative staff will not be out of place. It will help the working plan staff immensely if in the formation of societies this is guided by the policy of concentration rather than infiltration. This will not only ensure effective control by the working plan officers, but will reduce the number of working plans. Criticism is easy and I am all too aware of the imperfection of the above few pages. But in placing them before the conference I am confident that the methods described above if judiciously adopted in different divisions to suit their requirements will stimulate the production of working plans and enable the forest department to keep pace with the formation of societies.

NOTES ON SOME GOLD COAST TREES, COMPILED BY D. KINLOCH. PRICE 2s. 6d. GOVERNMENT PRINTING DEPARTMENT, ACCRA, 1945: I—X, 1—70, 1 MAP.

This is a companion volume to Gold Coast Timbers, published in 1941.

The Gold Coast has an area of 91,690 sq. miles, lies between 4° 45′ and 11° 10′ north latitude and has a population approaching four millions. The altitude varies from 1,000 to 2,000 ft. The heaviest rainfall of about 80 inches is mainly concentrated in the south-west corner, adjoining the gulf of Guinea further inland. Up to the scarp most of the area has a rainfall of over 60 inches, while north of the scarp the rainfall is below 50 inches.

The more important forest types (tropical rain forest, tropical Savannah woodland and the three edaphic formations, tropical riparian woodland, commonly referred to as fringing forest, tropical fresh water swamp and tropical mangrove woodland) found are described.

Specific notes relate to six exotics and 29 indigenous species. The notes are admittedly very elementary but not a few are of more than local interest, *e.g.*, suggested control measures for gall attack on *Chlorophora excelsa* and its two species.

The value of enumeration figures over 1,000 acres in the various reserves is of course of local interest only and it is remarkable that rotation ages are only known for the two exotics *Azadirachta indica* and *Cassia siamea.*

Terminalia ivorensis is one of the fastest of the native trees, a height of 50 ft. in seven years having been recorded. This species coppices to an advanced age. J. P.

EXTRACTS

FOREST BIRDS AND FOREST PROTECTION

By W. L. Taylor, C.B.E., F.Z.S.

In these days it is an accepted axiom that the forester's purview in regard to forest protection should be broadly based. We cannot afford to overlook any of the natural phenomena affecting the welfare of woodlands, least of all, perhaps the inter-reactions of the multitudinous wild life of the forest, because few, if any, of the animals and plants which populate our woods are without some significance in silvitulcure, great or small. The predominant consideration in the minds of foresters is the proper care and protection of the forest crops. That is understood by all who play a part in current British forestry, but in many directions our knowledge of the activities of nature in woodland remains scanty; in none more so than in regard to the day-to-day activities of many forms of animal life of the forest, the ways and means by which different species live, and their effects upon each other and on the trees. The life histories of some of these and the influences they exert are, of course, highly involved and operate for or against the survival of any given kind of life including that of the tree. Directly or indirectly some members of the forest fauna are beneficial to silviculture and some otherwise.

THE INFLUENCE OF BIRD LIFE IN FORESTS

So far as observation and research have gone, and research into certain of these matters has not yet gone very far, the influence of wild birds may be considered helpful to the foresters' efforts. It cannot however be denied that forest ornithology has hitherto suffered neglect, or that a study of the habits of birds in relation to forestry has not yet been systematically attempted in Great Britain to any extent. A limited number of forest-dwelling birds do physical damage to timber trees by bark and wood boring or bud-destroying. Others destroy seed. On the other hand some of them act as seed-carriers thus helping regeneration. Predator species police the woods, although, in excessive numbers, birds that prey upon others are harmful as they interfere with distribution both as to numbers and species. But in spite of the very wide gaps in our knowledge there is ground for belief that a sufficiently numerous bird population, properly balanced in regard to species, may be of considerable advantage in the woods and plantations, particularly as insect destroyers.

The notion is supported by published results of experiments in progress for some years before the outbreak of war at the Forest Research Station at Seebach in Thuringia, where some striking work has been done in the control of insect pests by attracting insect-eating birds in the nesting season. Investigations of the same nature have been in hand in the United States, Czechoslovakia, Hungary, and in some other parts of Germany, and British foresters may await the publication of further results with interest. In Great Britain small-scale beginnings have been made as to ways and means of attracting the hole-nesting birds, the Forestry Commission's experiments in the Forest of Dean and elsewhere being preliminary to more detailed investigation of bird-life, and bird habits and behaviour, in relation to forest protection.

THE INSECT EATERS

The most conspicuous value to forestry of a reasonably constituted woodland avifauna is the work of the birds in helping to control insect pests. The diets of the true insectivores consist almost wholly of insect life in one or another of its forms—eggs, larvæ, pupæ, or the mature insects in their final imago stage. The numbers consumed are prodigious, especially of caterpillars during the nesting season, a period in which insect life is particularly vulnerable. Many resident birds as well as summer visitors take advantage of the prolific fare provided at this time and all of them should be encouraged to breed in our woods. The warblers, goldcrest, wren, robin, redstart, flycatchers, hedge sparrow or dunnock, nuthatch, tree-creeper, wryneck, nightjar, and the woodpeckers, keep up incessant warfare against insect life and help to cleanse tree-growth from infestation. Titmice maintain a constant search for eggs, larvæ, and pupæ, among the branches, twigs, and leaves, all the year round. The cuckoo is peculiar among insectivores on account of its predilection for the hairy kind of caterpillars. Nightjars devour chafer beetles among other species, and others of the common birds, including sparrows, hawk and kill mature chafers and other flying insects, the flycatchers also taking their insect prey on the wing.

The hard-billed seed eaters render very valuable seasonal aid towards the destruction of insects. Their nestlings are nourished almost exclusively on insect food. Collinge in his work on bird dietaries found the chaffinch, great tit, blue tit, and house sparrow, and the wren, thrush, blackbird, and starling, particularly assiduous in this respect, the first mentioned, the blue tit, and wren, bringing 100% of insects to their broods, the others feeding 100% of animal matter to their young, including high proportions of insects. More research is badly needed into the feeding and other habits of forest-dwelling birds and into the means by which the most useful species can be induced to breed in the plantations. Except the *Columbidae* practically all forest species include insects in their menus at one time of year or another and even the woodpigeon has been seen to eat the larvæ of *Tortrix virudana* on occasion. When it is realised that nestlings will consume more than their own weight of food per diem in course of the first few days after they are hatched, it is possible also to realize the enormous destruction of insect life wrought by the activities of parent birds.

Woodpeckers prey chiefly on bark-hunting insects; their help as a check to the ravages of elm disease (*Graphium ulmi*) by destroying spore-carrying bark beetles may be more valuable than has been realised. The physical damage to timber by woodpeckers may well be considered negligible by comparison with their work among bark insects—it does not amount to very much in any case. All these birds want is a few old trees in the woods to give them something to peck at and to provide nesting holes—our zeal for clean, even-aged plantations may sometimes be carried too far in this respect. There cannot be much doubt that woodpeckers should be encouraged. American ornithologists take this view.

Exceptional infestations attract birds of more omnivorous habits as in the case of the large larch sawfly attack in the Lake District some forty years ago, when rooks, jackdaws and starlings were observed to be busily engaged in and about the severely affected plantations, pine plantations in Rendlesham Forest, Suolkff, which were heavily attacked by the pine-sawfly in their earlier stages, drew the attention of gulls, among other species. These are special instances of seasonal insect destruction and many such must occur. Recorded observation, however, gives very few examples of bird behaviour amongst the trees in exceptional conditions.

It is to be hoped that the extensive war fellings of pinewoods in the valley of the Spey and elsewhere in the north-east of Scotland will not adversely affect the status of the crested tit; also, as time goes on, that it may be tempted to extend its range farther afield to some of the new conifer forests planted since 1919.

RAPTORIAL AND PREDATOR BIRDS

Carnivorous birds, the hawks and owls, live on animal food, also to a considerable extent do the omnivorous *Corvidae*. These birds kill rabbits and lesser rodents, the buzzard being a habitual rabbit killer. Owls are indispensable as a check to the extreme fecundity of mice and voles. Most of the hawks, especially the kestrel and even the sparrow-hawk, do not despise beetles and others of the larger insects, while the much abused little owl normally eats 49% of insect food, including 10% of weevils. The vilification of this introduced species has been somewhat overdone and the "Little Owl Food Enquiry" published under the auspices of the British Trust for Ornithology in 1937, might be more widely read. Of course nearly all these killers, birds of prey and others are destroyers of smaller birds or their eggs and, if they are present in undue numbers, they are a danger to the balance of the woodland bird population as a whole. Hooded and carrion crows, jackdaws, magpies, jays and sparrow-hawks, can be a nuisance and need to be kept in check but the rarer hawks, and kestrels, ought never to be wantonly destroyed, nor should the raven, a relatively rare and interesting member of the British avifauna, be molested to the extent it frequently is. It is of interest to note that buzzards and ravens have nested for several seasons in West of England plantations planted by the Forestry Commission since 1919. Owls should be given complete protection by foresters. Even this fact is not everywhere fully realised.

The preservation or otherwise of raptorial and other birds that are capable of mischief are controversial matters as common knowledge of their habits stands at present. It should however be remembered that several of them are fast becoming rare and that a British race or species once lost has gone for all time. The white-tailed eagle and osprey have disappeared as breeding species within a generation. All the carnivores develop an occasional "rogue" and if any individual takes to bad habits it can be dealt with without waging a war against the whole tribe.

SEED AND FRUIT EATERS

It may appear a simple thing to classify birds into insect-eaters and those depending chiefly on fruits and seeds for their livelihood. Actually feeding habits vary considerably according to locality and the seasons; as stated already many species resort to an insect diet for their young; they also do so in part for their own sustenance at other times of the year. Although in the main the hard-billed birds are fruit or seed-eaters, there are few species that are exclusively so. With some kinds of fruit-eaters the seeds are passed on uninjured and viable but true seed-eaters digest and destroy the seeds consumed. The former are of assistance in natural regeneration although the plants spread by birds in this way are largely forest weed species as the upgrowth of bramble, elder, holly, and yew, testifies in plantations frequented as roosting places by thrushes, blackbirds or starlings, wherever the canopy admits enough light to permit any sort of understorey to exist. Rooks, crows, jackdaws, jays, and pigeons, are carriers of the larger tree-seeds, all being eaters of acorns and beech mast, especially wood-pigeons, which have been shot with up to 100 acorns in their crops. Pheasants are greedy eaters of acorns, occasionally consuming more than they can hold. Again they also eat a large proportion of animal (mainly insect) food at other times. The one hard-billed bird known to crack the hard nuts of the hornbeam and eat the kernels is the hawfinch.

Chaffinches and some others of the finch tribe pick up a great deal of the seed shed annually by conifers and all the seed so eaten is destroyed in the process of digestion. Crossbills destroy quantities of cones for the sake of the seed and altogether the quantity of conifer seed eaten by birds must represent a heavy toll in the annual crop in some districts.

BIRD HABITS THAT ARE HARMFUL

In the interests of agriculture, foresters should not harbour wood-pigeons. They do no great harm in the woods except as mast-eaters but they do no obvious good, while the damage a flock of wild pigeons can do to farmers' green crops is serious where these birds are plentiful.

All the crow tribe are apt to be mischievous neighbours and exceedingly few people have a kindly word for the "hoodie."

Woodpeckers bore into the bark and wood in search of food or for nesting places. As already mentioned the sum total of permanent damage in a healthy forest is negligible by comparison with the numbers of harmful insects destroyed. Tree-creepers and nuthatches do little harm. All hole-nesters are, however, given to digging out and enlarging rotten knots to accommodate their nests. It is said of the tree-creeper that it habitually kills predator as well as injurious insects, but this may also be true of other insect-eaters. We do not know.

Capercailzie live chiefly on the buds and shoots of conifers, notably Scots pine, and those who have tried to establish Scots pine where blackgame are plentiful well know how much damage these fine birds can cause. At least part of the broken new season's shoots of Sitka spruce are snapped off by the weight of the heavier perching birds. Crossbills destroy buds and shoots as well as seeds. Bullfinches are notorious bud-eaters and are frequently to be seen among the larches. They probably do little permanent harm to forest trees, and where bud-destroying by tits is observed, more often than not a hidden grub is the quest.

Where large numbers of birds congregate for roosting they become a nuisance. Starlings are always unwanted bedtime guests and may do irreparable damage in plantations when they come in their incredibly large autumnal and winter flocks; but, contradictory as it may seem, starlings can with advantage be encouraged to nest in the woods, especially in the vicinity of the forest nursery, on account of their insect destroying propensities during the breeding season. Moreover there is no fear that the attraction of nesting starlings to a wood will influence their choice of a roosting place later in the season.

There is one other point. We do not know how far birds may be responsible as carriers of spores of fungi and for the spread of injurious fungi among the trees. There is also the risk with the bark-borers that they may provide means of access for the spores to the cambium.

On the whole there is little to be alleged against the bird-life of the forest, in spite of occasional, and usually local, damage.

HOW TO ENCOURAGE WOODLAND BIRDS.

Birds are classified as residents and seasonal visitors. To be content wild birds require a suitable habitat, shelter, food and water, appropriate nesting places, and a measure of safety from foes. In general, most species shun draughty woodland and woods in which water is not accessible. Broadleaved and mixed woods attract more kinds of birds than pure conifers; the possible range of woodland species is considerable. Nevertheless some of the old hardwood areas about the country are singularly poor in bird life and there are a number of birds which frequent, or can be induced to take up residence in, conifer plantations, either permanently or seasonally. Suitable nesting accommodation is of first importance in a forest. The true insectivores, warblers and such like, nearly all nest close to the floor of the forest among brambles and bushes growing along ride-side and in the more open glades. There is no inducement where the forest floor is bare and the canopy dense; the only remedy is to provide wide rides and to tolerate low-growing minor species, some of which also provide berries and seeds for the seed-eaters. A silviculturally well-managed, even-aged wood is often a desolate place for small birds; in such surroundings, too, the hole-nesters find few homes for their families. So far as the tits, redstart, nuthatch and robin are concerned, the answer lies in the provision of suitably constructed nesting boxes, experience in Thuringia pointing to the need for accommodation for two nesting pairs per acre in order to secure a satisfactory degree of protection against caterpillar attack. The provision of at least three artificial nesting places to each acre is necessary to ensure occupation at the correct distribution.

Birds must have adequate food and shelter. A hard winter plays havoc with bird populations throughout the country and artificial feeding is impracticable on any appreciable scale. In unnatural surroundings, and in the absence of suitable covert, wild birds more easily fall prey to their enemies and to hard weather. Changes of environment at once react on the distribution of bird life, as when bare land is afforested or woodland is felled and replanted. In such cases a forest bird population must be built up afresh; a little attention to the birds' requirements from the beginning will help to populate the growing plantations with an

avifauna rich in species and numbers according to the degree of comfort the forest offers.

EXPERIMENTS IN FOREST BIRD ATTRACTION IN GREAT BRITAIN

In the winter of 1942 a small experiment, directed towards the possible control of *Tortrix viridana, Cheimatobia brumata* and other leaf rollers, which from season to season defoliate the oak woods more or less severely, was commenced in the Forest of Dean, in Gloucestershire. A suitable type of nesting box, a modification of the Westphalian nesting-box,* was adopted, 84 of which were put up in a selected area of 130-140 years' old oak (37 acres) in Nagshead Enclosure. 38% were occupied in the first season and broods were brought off. During the following year 10 additional boxes were put up in Nasgshead Enclosure and 70 more in a 35-acre block of Perch Enclosure nearby. The percentages of success were 65% in Nagshead and 69% in Perch. In 1944, 126 boxes were successfully occupied out of a total of 162, representing a 75% success, the species attracted being pied flycatchers (65 pairs), great tit (34 pairs), and blue tit (21 pairs), together with redstart (3 pairs), and nuthatch (3 pairs). The Forest of Dean experiment is being continued and, during the past winter, has been extended in a small way to other forests, under the general supervision of Mr. W. H. Guillebaud, Chief Research Officer of the Commission. Results in the Forest of Dean have been systematically recorded, but it is yet much too early to determine positive results. It has however been demonstrated that the birds soon accustom themselves to properly erected boxes and use them freely. It may also be claimed that additional pairs have been induced to breed in the Forest of Dean. This is proved by the high proportion of nesting pied flycatchers—a species rarely seen in the Forest previously and not observed to have bred there. When the troubles and restrictions of wartime are over it is intended to organise the experiments on a proper scale, and on a systematic basis, throughout selected areas of the Commission's Froests, conifer and broad-leaved, both in Scotland and England and Wales. Ways and means to attract the soft-billed insect-eaters also require investigation.

OBSERVATION AND RESEARCH

Foresters might well pay more attention to the ways of the birds to be found in their woods. Investigation into economic ornithology in regard to agriculture as well as forestry has been hindered for want of practical interest and public support and bird populations are intimately related to both these industries. In this we have been behindhand in Great Britain, much more so than some of the continental countries and the United States, the Governments of which have seen to it that attention is paid to wild life problems. Bird migration has received attention but the true economic status of British wild birds is urgently in need of scientific investigation and assessment. Certainly forestry in Great Britain ought no longer to ignore the study of the habits and dietaries of woodland birds.

THE WILD BIRDS' PROTECTION ACTS.

It is regrettable but incontestable that existing legislation has largely, if not completely, failed in its objects. The legal position of our wild birds is far from satisfactory. No fewer than nine Acts of Parliament form the basis of the law as it stands at present but ornithologists cannot view the position with any degree of equanimity. The law lacks precision and there has been, and is, widespread absence of knowledge of bird lore, consequently the Act of 1880, and subsequent enactments, have proved all but impossible to administer. Much that is illegal is still done without let or hindrance. An overhaul of the existing Bird Protection Acts is overdue, but in the absence of reliable and widely drawn data it remains far from an easy matter to void the pitfalls of sentiment and prejudice and to frame wise laws. The need for a new and comprehensive Act, capable of being properly administered, is acknowledged and urgent. It is equally necessary systematically to organise the further investigation of our bird problems in forest and field.

So unsatisfactory are the measures for the protection of birds in general in Great Britain that the effective preservation of our rare species, notably the kite and honey buzzard, is dependent upon private interest and privately subscribed funds rather than on the law of the land. Neither sentimentality nor prejudice is any help; detailed knowledge of bird habits and behaviour on which to base new and workable provisions for bird protection is what is wanted. In this there is a part for British foresters to play.

*Described in *Forestry* Vol. XVIII, 1944.

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GRAZING AND LIVE STOCK GROWING IN NORTH AFRICA

By John R. Killough

Formerly a member of the National Park Service and the Grazing Service, now with an Army Topographic Mapping Unit in North Africa.

The description of grazing and livestock growing in North Africa is based on the author's personal experience as a member of the armed forces. It is a drab picture.

Most of us have associated North Africa with the great Sahara Desert, a vast sea of sand dunes and a few isolated oases. However, there is a wide belt between the Mediterranean Sea and the Sahara that bears no resemblance to this romantic conception. This broad coastal belt bordering Morocco and Algeria on the north is, on the contrary, composed of a series of steep mountain ranges, joined by rolling hills and interspersed with many fertile valleys.

The mountains of this area rise abruptly to altitudes varying from 3,000 to 6,000 feet. As a whole they are sparsely covered by dwarf pine, juniper, live oak, olive, and locust trees along with many tough, xerophytic shrubs. Due to thier coarse, thorny nature most of these trees and shrubs are valueless for grazing. The three major browse families represented are the Rosaceae, Leguminosae, and Compositae. During the rainy season, which lasts from mid-September to early June, there is a ground cover of forbs and grasses. This ephemeral understorey constitutes practically all the vegetation suitable for grazing. Among the forbs are common mallow, lappula, phacelia, numerous species of mustard, asterfl eabane, thistle, poppy, and spu rge. The Compositae, Liliaceae, Leguminosae, and Umbelliferae make up the greater part of the forbs here. The annual grasses predominate, the most common genera being Poa, Agropyron, Bromus, Hordeum Sitanion, Avena, Elymus, and Lolium. Carex is comm on on the dry foothills and Juncus. may be found along the many streams intermittent

The rolling hills and tablelands support much the same vegetative cover as the mountains, though trees are less common and shrubs more abundant. In fact, the live oak brush is so dense in some areas that it becomes impassable for both man and livestock.

With hardly an exception, the valley lands are all under cultivation. Here the soil varies from a heavy clay to a rich clay loam. Small grains do exceptionally well and all truck garden crops are grown with success under irrigation. Fruit trees are plentiful. Grapes are probably the main fruit crop in this region, and large vineyards, cultivated in terraces, are located both in the valleys and on the hillsides.

The climate during the rainy season is moderate. Light frosts and occasional snow may be expected in the mountains, although temperatures seldom drop much below the freezing

point. The summer months of June, July, and August, however, are extremely hot, and temperatures of 125 °F and above are not uncommon. In August the dreaded hot winds from the desert sweep the country. The "siroccos," as these winds are called, seldom last more than three or four days, but during this time all activity ceases, man and animal alike seek shelter from the intensely hot blasts of sand and wind. During these summer months of no rainfall, only the larger streams and rivers continue to flow. Thus water for both livestock and man is scarce. This wide seasonal variation in rainfall and temperature limits the native vegetation to drought-resistant shrubs and drought-evading animals.

The soil of the entire area is basically clay. The watersheds are susceptible to both sheet and gully erosion because of sparse vegetation, steep slopes, and the low content of organic matter in the shallow top soil. The valleys accumulate more top soil, which is high in organic material. Under proper cultivation and irrigation the valley soils of this region are among the most fertile in the world.

Agricultural methods are still primitive as a whole, though many of the French, Italian, and Spanish immigrants employ relatively modern methods. The natives still use many wooden plows, pitchforks, and other implements as well as harvesting most of the grain by hand. Oxen are the main source of farm power, along with horses, mules, burros, and to a very small degree camels. It is common to see oxen, horses, and mules all hitched to the same wagon or plow, pulling together in awkward unison. Native human labour is cheap and plentiful.

Livestock of all kinds is abundant throughout the area, and the methods of husbandry are far more antiquated even than the agriculture. There are practically no distinct breeds among the sheep, cattle, and goats although there are a few excellent horses. Selective breeding is non-existent; stock is marketed and slaughtered at random with no apparent attempt at culling or standardizing the herd.

In no instance does stock run at large either on the open range or in fenced pastures. Though gardens, vineyards, and orchards are fenced, there are no fenced ranges. Sheep and cattle alike are herded in small bands seldom exceeding forty head. The herdsmen are generally Arab children. At night, the herd is driven into the owner's courtyard, for nearly every house in the region is built around a courtyard. The mere thought of quartering livestock in the house is distasteful to us, but here it is a necessity. Thievery and rustling are so common that even the vineyards must be kept under armed guard at night. Small bands that can be easily manoeuvred and protected are therefore more convenient. This practice makes branding and marking unwarranted and would also, if any attention were given to breeding, eliminate the need of bull laws.

Male animals are seldom castrated, except those used for working stock, which are emasculated at the age of two or three years. There are no polled cattle and dehorning is not practised. Sheep are not docked, dipped or cared for in any manner, nor are they often sheared, for the wool here is short and of very poor quality. Goats are raised as extensively as sheep, and this area has probably gained more note for its kidskin and Moroccan leather than for any other product.

Despite adverse conditions caused by flies, insects, heat, and the general lack of sanitation, disease is not common, though cholera, anthrax, and Brucillosis are present to some extent. The more progressive husbandmen vaccinate for blackleg but the vast majority of livestock receives no protection. Malnutrition probably causes greater stock mortality than do bacterial diseases. Predatory animals are little or no problem because stock is so closely herded and guarded. Jackals occasionally take off a few lambs, and it is said that some sheep and calves have been lost to hyenas.

Plants poisonous to livestock are not abundant enough to be important, if they occur at all. None of the stockmen questioned could give any instance of losses from this source. There are, however, many mechanically injurious plants among the thorny thistles, shrubs, and cacti. Many grasses and forbs have sharp, barbed awns which lodge in the gums or eyes of the animals, causing an irritation similar to "lumpy jaw" or actinomycosis.

The grazing season is yearlong, but during the summer months the native forage becomes so dry and sparse that supplemental feeding is necessary. During this period animals are pastured extensively on grain stubble and to a lesser extent on cultivated permanent pasture. These permanent pastures are usually planted to

various mixtures of clover, bur clover, lespedeza, alfalfa, and perennial and Italian rye grasses. Grain and oat hay is one of the preferred dry supplements.

Water is a grave problem for man and animals during the dry season. There are a few permanent streams, but most of the watercourses are intermittent and dry for three to four months of the year. Wells may be obtained in most of the lower valleys, but on the whole these are not well situated for best range livestock use. There are innumerable sites where all earthen stock tanks could be constructed and the clay soil would hold water well. No advantage, however, has been taken of this source of stock water.

One would assume that stock in such an arid region would require a great deal of salt, yet salting is not practised and there are no visible evidences that this has proved harmful.

Without question, the chief factor governing the livestock industry in North Africa at present is not the physical environment but rather the people themselves. Although there are many French, Italian, and Spanish immigrants, the population is predominantly Arabic. The habits, customs, clothing, language, religion, and other aspects of civilization, though changed somewhat in local areas by European immigration, have as a whole remained exactly as they were many centuries ago. The numerous tribes and castes of Arabs differ greatly from one another, but from the highest to the lowest classes the people have preserved their individual ways of living.

All but a few live a life of extreme poverty, housing themselves in mud or brush hovels, with barely enough space to accommodate the entire family at once, and not a stick of furniture or a bit of privacy. Disease of all kinds is so common that an Arab without an affliction is the exception rather than the rule. Marriage among them is strictly a business proposition in which the bride is merchandise and sells for cash. No romance enters into the bargain for the groom sees naught of his bride before the marriage ceremony, except one eye and her bare and usually dirty feet. If he is not sastisfied he can buy another, for they are still polygamous. Only the smallest minority has received any education other than that handed down by word of mouth for generations. They live for the day, and to-morrow never comes. As a result, all of their social processes are backward and whatever improvements are made must come from a more advanced country.

The livestock industry in North Africa offers little to help us in improving range management in the United States. It is merely a matter of interest and curiosity. Grazing, however, is major industry, and in the post-war period may be called upon to supply the meat demands of the devastated European continent. We, as a major power, may be obliged to aid many such countries to fit into the social and economic balance of the world at the close of the war. Consequently, some knowledge of their present methods and problems will be of great value when our help is needed. Here, too, is a new frontier for men trained and educated in range management and range economy.

Journal of Forestry, Vol. 43, No. 5, dated May 1945.

PIECE RATES IN FORESTRY

Nearly all the money we spend in forestry goes to the payment of wages. It is therefore a matter of first importance that labour should be as productive as possible and output per man-week becomes a primary consideration. A reasonably high wage is rightly demanded and unless forestry can pay as high wages as other industries and can provide as good conditions for work and living it cannot hope to keep a good type of labourer.

This problem is common to all industries: how to pay a high wage and yet get work done reasonably cheaply. One solution is provided by mechanization and the conveyor belt, but this method is applicable to forestry only in a minor degree. Another method is by very strict supervision under forceful leadership. This may be successful with a small contractor who works with his men but is often impossible on a scattered estate where the men work in small gangs. The most hopeful solution in forestry is by means of piece rates and bonus payments and this method should be adopted wherever practicable on estates.

The influence of piece rates on woodland labour is rather different from their effects in in a factory. The scattered workers in a wood

cannot be closely supervised and in most of their operations they become individually responsible for the order of their work. The choice of which tree to fell next, whether they lop one before felling another, whether they bundle pea sticks as they cut them or wait till they have many bundles to tie and a host of other questions of this sort must be decided by each worker. Some will work better one way and some another and if a detailed order is imposed on them some of them will feel frustrated and work less enthusiastically than they might.

If men are working on day rate they have little inducement apart from their pride in their work to use their time as effectively as possible; but when they are paid by results they are immediately stimulated to discover and adopt any device which will increase their output. They will emulate the best in efficiency. In other respects, too, their interests become identified with those of their employer. If one job is finished they must be supplied with another immediately. If the machinery they are working with, such as a sawbench, requires repair or renewal, they will rightly refuse to use it and they must be put on to other work until the necessary repairs are effected. It is a loss to the employer if men waste their time with an out-of-date machine, but when men are working on day rate it is quite possible for them to go on using it without pointing out its deficiencies.

It must be a part of the contract that men should earn higher wages on piece rate than on day rate. It is a fair generalization that piece rates should be graded so that the average worker should be able to earn about 25 per cent. more than the minimum wage; this means that outstandingly good workers will at times earn 100 per cent. more than the minimum wage, and the employer will be benefited by his doing so. Some workers, on the other hand, may at their best earn less than the minimum wage, and since, so long as they work full hours, they must be paid the minimum wage, the system may break down in their case. There will always be inefficient workers and we must find employment for them; and it is a merit of piece rates that they enable us to discover with certainty which of the men are misfits; we can then take steps to put them on to work for which they are better adapted.

Workers must receive the minimum wage if they work the full week. To this extent it is necessary to watch the times at which they start and finish. But when men are working satisfactorily their earnings will regularly exceed the minimum and they can manage their times as they like. This gives them far greater freedom and a sense of being their own master and it frees the forester from one of his most unpleasant and difficult duties; often in forestry it is quite impossible to watch the hours of the men, and this is particularly the case with workers who live in isolated cottages near the woods. Many countrymen are meticulous timekeepers and work steadily whether they are paid by time or by piece; but men working on piece rate will work overtime when it suits them and this will usually be to the advantage of the employer. The fact that they can take time off when they want to makes them more independent.

In some operations piece rates allow of an astonishing reduction in cost. The evidence of tested instances shows that in such work as felling, clearing top and lop, and manufacturing firewood and pea and bean sticks the cost on piece work may be between a half and a third of the cost on day work, even with steady workers; although the men earn considerably more and work with greater zest. This seems to suggest that on day work the men must be slacking. We can never be quite certain what men are doing when we are not on the spot; but in most cases it would probably be found that they work steadily but without the scheming and energy which they will devote to the job when they are paid by results.

Piece work is attended by disadvantages as well as advantages, and these must be squarely faced. In the first place workers may be tempted to over-exert themselves and for this reason piece work is often considered undesirable for women and boys. If it should result in greater proneness to accident this would be a serious argument against it, but there is no evidence in forestry that such is the case. Accidents are more often due to inattention than to over-exertion, and a definite routine of work is conducive to safety. It is not necessary in forestry to press down the rates to such a level that men can only earn a living by working unduly hard.

Another argument against piece rates is that the earnings of the men become unequal from week to week, which tends to make them improvident. Their earnings may be affected not only by variations in the nature of the woods but much more seriously by weather. Also, there are some men who do not respond to piece work or who become worried by the fear that they cannot produce as much as their companions. These men are generally in a minority and, as there is plenty of woodland work which is not adapted to piece rate, other work can be found for them.

Piece rates demand special knowledge and skill on the part of the forester. This skill is required, firstly, in fixing the rates; secondly, in finding a suitable unit of measurement for the piece; thirdly, in ensuring that work is not scamped; and fourthly, in checking the amount of work done. As piece work lessens the importance of daily supervision it will, in general, reduce the amount of his work but make greater demands on his skill and forethought.

Woodland rates can seldom remain constant over a long period. Owing to variations of the soil, the steepness of the ground, the size and shape of trees and the nature of the undergrowth, it is necessary to offer different rates, even for the same operation, in different woods or even in different parts of the same wood. It has been the custom to pay $1\frac{1}{2}d.$ or $2d.$ per cubic foot (O.B.) for felling and lopping hardwoods, but higher rates are necessary for felling heavily branched hedgerow timber, which requires much more work per cubic foot of bole. An intermediate rate may be suitable for short boled trees growing in a wood and a rate less than the standard rate may be applicable to tall drawn trees with scanty branches. If the operation is a selective felling or a thinning, the men should be paid an additional rate on the understanding that they are careful not to damage the remaining trees. It is undesirable to change the rate more often than is necessary as it encourages unprofitable argument; and men are reasonable enough to accept the fact that sometimes they are out of luck so long as they have compensating periods when they can earn their money easily. Nevertheless, variations in rates are often an advantage to the forester since, when a rate is fixed for a particular wood, he can experiment more freely and encourage men by high rates for particularly difficult jobs. He is not bound to maintain these rates subsequently.

In some parts of England it is usual to pay a rate of 6*s.* a cord for cutting top and lop into 4 ft. lengths and stacking in cords. Since firewood in 4 ft. lengths is now seldom used and as long firewood is cut into blocks on a bench, it is a waste of time to cut top and lop into such short lengths; and it is becoming more usual to leave it in 8 ft. to 10 ft. lengths and stack in ton heaps. But it is more difficult to estimate heaps of long firewood than it is to judge cords and there is a tendency to retain the cord simply because it is an easy measure of piece rate. It has not been found unduly difficult, however, to learn to recognize a ton of long firewood and errors in estimation can later be rectified if a record is kept of the firewood blocks which are subsequently sold.

It has been found that, with the minimum wage at 70*s.* a week, 4*s.* 6*d.* to 5*s.* a ton is a siutable rate for breaking up top and lop into long firewood; but if the branches are very heavy, or if such scrub as holly and rough poles have to be cleared at the same time, a higher rate may be necessary. If the brush has to be burnt, an inclusive rate for a complete operation may be arranged . In one rough wood, where the recently felled tops were scattered among groups of large holly, stunted and twisted oak poles, overgrown hazel bushes and other rubbish, it appeared likely that clearing would prove very expensive. A composite piece rate was arranged of 12*s.* a ton for long firewood ,5*d.*, 8*d.* and 1*s.* 6*d.* for bundles of pea sticks, bean sticks and thatching spars respectively, and 9*d.* each for oak logs $5\frac{1}{2}$ ft. long suitable for cleaving into fencing stakes; the men, however, had to burn the brush and leave the ground ready for planting without additional pay. These rates were fixed so that an arduous operation might be completed, and the three fellers, who worked as a team, were able to earn an average of more than £5 a week. But all the products were worth more than the piece rates so that very difficult ground was cleared at a profit. Nevertheless, these rates only applied to this wood and new rates would be fixed for other woods according to their contents.

The fixing of rates is often experimental and the forester who is responsible for them

must have a fairly close idea of the amount of work which a man should do in a day. At any reasonable piece rate the cost will be lower than if the men are paid by the day, so it is not necessary for him to attempt to make the rates as low as possible. The fact that a really good man is earning £6 a week need not mean that the work is expensive; indeed, the forester should be ready to congratulate his men in getting through a job quicky.

The success of piece rates is dependent on a happy relationship between the forester and his men. He should consult them about his objects and the methods to be followed and explain to them the grounds on which he has estimated piece rates. There will be occasional bargaining, but as the forester will be dealing with only a few men at a time there should be little cause for misunderstanding.

The measurement of work done is usually based on some unit though in some instances a price may be arranged for a complete job. The unit of felling is the cubic foot, pitprops are counted and the products of coppice are readily measured. Firewood, as already pointed out, is more difficult unless the out-of-date cord is used as a measure. The burning of brush may be done by the square chain or it may be paid for by a higher rate on concomitant work. Hedge laying, paring and ditching may be paid for by the chain. Planting is usually measured by the number of plants and weeding by a unit of area.

To institute piece rates in some of the simpler and more straightforward operations of forestry is an easy matter. But to extend it into the complicated day-to-day work of estate woodlands demands constant attention and ingenuity on the part of the forester; it is the kind of management that only a highly paid man can be expected to do. Unless he is extremely careful, one operation will outpace another, transport or material will not be available when required, and the next job will not be ready when the first is completed. The work has to go with a swing and the men must be kept constantly employed. This demands a great deal of forethought and constant attention, and at times the position will become so intricate that a lapse into day work is unavoidable. In any case, some day workers will be required to do the odd jobs so there is always room for old men and for those who are not adapted to piece rate. There will always be some compromise between the two methods of pay.

Piece rates are often disparaged on the ground that they encourage scamped work and that they are antagonistic to the spirit of skilled craftsmanship; for instance, many foresters refuse to plant by piece rate because they fear that the planting will be imperfectly done, and they can quote examples where undue losses can be ascribed to this cause. This is almost certain to happen when novices are pressed to work faster than their skill allows. It may happen equally with day work when youths are put on to planting with a gang of more experienced men and do their best to keep up with them. What is essential is that youths who come into woodland work should be well trained from the first; once they have learnt to do good work it will not be too difficult to induce them to maintain a high standard whether on piece work or day work. And the sustained routine which men acquire on piece work is often more conducive to quality than the more intermittent effort which is often observed on day work.

—*Quarterly Journal of Forestry, Vol. XXXIX, No. 2. July,* 1945.

ALTERNATE HUSBANDRY

When the full story of food production in Great Britain and other European countries during the second world war is written, the part played by what in agricultural literature is now known as alternate husbandry will find a prominent place. With the opening of the war in 1939 problems of homegrown food production for man and livestock loomed large. In Britain it was to the reserve of fertility represented by the many thousand acres of permanent and semi-permanent and often neglected grass lands that those responsible for producing the nations' food immediately turned their attention. Events proved that this reserve of fertility consisted of something real which responded to cultivation and expressed itself in high yield of cereal crops contributing, in a handsome measure, to the food supply of the nation during a very difficult period.

Prior to the war, experimental work in Britain and elsewhere had shown that grass and herbage crops, particularly legumes grown in association with improved strains of grass species could, under suitable systems of management, effect considerable improvement in the crop yielding capacity of the soil. This improvement could be explained in terms of increased supplies of humus, plant nutrient both as nitrogen and mineral, and in changes in the soil structure which had a decidedly favourable influence on the growth of succeeding crops.

The actual period of time required for this improvement to take place varied with the types of herbage crops used. It is seen, however, that certain clovers in association with suitable grass strands could, in one or two years, create an accumulation of fertility sufficient to justify their inclusion as an integral part of normal crop rotations over considerable and very diverse areas. Experimental research had already resulted in the adoption of suitable systems of management under which such rotations produced not only more fodder for livestock, but by virtue of the fertility accumulated during the herbage crop phase, more actual food crop on the same area. In countries where animal products have an importance equal to that of food crops as integral parts of a balanced economy, the importance of such a development was quickly appreciated. Not only was this true of Britain, but of all those other countries driven to policies of self sufficiency by the exigencies of the war.

Alternate husbandry has been defined as the planned and regular alternation on every field of an agricultural unit, of a period of arable husbandry, for the production of crops for human consumption, industry or animal fodder, with a period of direct animal use in which the composition of the forage mixture is adjusted to provide the maximum amount of fodder of the proper type for the animal crop and to provide at the same time for the optimal state of fertility in the soil throughout the whole course of the rotation.

Clearly it is not a practice which can be adopted under all agricultural conditions even with considerable adjustment and modification. If, however, it can be proved that the cultivation of herbage species in any area does result in soil improvement, a definite claim for consideration is immediately established. The various factors which affect its adoption will need critical examination. Among the questions concerned in any particular area are water supply, the availability of suitable herbage species, their establishment and management under what may be extreme conditions, problems of animal husbandry and animal health and the local markets and economic conditions under which the cultivator of the area is operating and which ultimately govern the extent to which an economic return is possible and compatible with the maintenance of soil fertility by this or any other means.

The reader may wonder what the source of this accumulated fertility can be and why grass species behave in any way differently from the other gramineous plants as wheat, rice, barley, sugarcane. The Indian cultivator knows the value of legumes both as food and soil fertility conserving crops and usually provides a place for them in his rotations. The soil improving value of fodders such as lucerne, berseem, *Senji*, *shaftal*, etc. is also well appreciated wherever irrigation facilities permit of these crops being grown. Usually they are cut and fed in the stall; the practice of feeding direct off the land by tethering or loose grazing is adopted only on a limited scale. So the return of animal excreta to the soil, if at all, is indirect. The period of direct animal use of cultivated land in India is limited to that required to graze off the crop stubbles after harvest. The fertilizing value of this method has yet to be demonstrated in this country. Actual grazing during the growth of a herbage crop is often harmful to the crop under Indian conditions, and pastures, particuarly on heavy soils, are severely puddled by grazing animals during the monsoon, and grass growth is consequently adversely affected, though such grazing under control has been found absolutely necessary in European countries in order to maintain a proper balance between the various types of herbage plants which constitute the mixture. Green manuring with leguminous crops is a type of alternate husbandry which is gradually finding a place in Indian agriculture. But in this, as in all other methods which aim at soil improvement for increased crop yield, there will arise special problems which will require special examination under the particular conditions of the area concerned.

Since in normal times in India, the value of animal products in relation to fodder crops is lower than in those countries where alternate husbandry has taken root, interest in the method will depend on (1) the extent to which the fertilizing value of herbage and forage crops can be developed and expressed as increased food of money crop yield, (2) the extent to which the market for milk and dairy products as well as other animal products can be developed to bring about an equalizing adjustment of the marketable value of food crops and of forage and herbage crops as expressed in animal products. It is claimed that the fertilizing value of herbage crops springs as much from the character of their root systems and its effect on the soil structure as from any humus and plant nutrient additions to the surface soil layers. The importance of the subterranean portion of herbage plants, it would appear, is no less than the subaerial portion. The mass of entangled and intertwining roots of varying degrees of thickness and thread-like fineness, perforates the soil in all directions and after to considerable depths. This root system changes the character of the medium in which it lives, slowly creating a granular structure which differs considerably in many properties important to crop growth. These properties are porosity, permeability, water retentiveness and aeration which altogether decide the growth of those food crops which are grown subsequently. It is known that under the effect of cropping with single food crops, as wheat, the soil tends to deteriorate in regard to these very desirable properties and that a period of recovery under the soil improving influences of herbage crop is necessitated for the reconstruction of the desired soil structure. The normal recourse is to fallow but there is evidence that a herbage crop is better. Given such soil conditions all factors concerned in crop growth operate to maximum efficiency. In soils lacking this desirable structure type, these same factors can express themselves only to a limited extent.

The idea is attractive and calls for examination. There is no lack of evidence of a general character to support it. The removal of grass from the western prairie belt of the American continent and the subsequent creation of the well known 'Dust Bowl' was not due merely to loss of grass cover but also to loss of soil structure which severely reduced the productive capacity of these soils and at the same time rendered them liable to erosive influences. There is much experimental evidence available to show that such soil structure can be built up just as it can be destroyed, that it can be measured and that fair correlations are observable between such measurements and crop yields. The practice of mixed cropping so widely adopted in many parts of India has never been fully explained . Quite different root and soil interactions may take place when mixed root systems are involved as compared with what occurs in the case of a single species, resulting in the formation of a soil structure more suitable for crop production under the arid conditions where it is practised.

The development of grass swards, temporary leys and permanent pastures exactly as understood in Europe cannot be envisaged in India. Under irrigation, however, good substitutes are possible and the range of fodder crops of both grass and legume species is considerable. In the tubewell areas the necessary facilities are available and provided it can be shown that the growing of forage crops is accompanied by increased yields of food and money crops resulting from an improved soil fertility, there is no reason why the system should not take root and develop on these lines. Research may show that with modifications it may have something to offer to other areas, not only in the restricted sense of crop husbandry but in the wider sense of tree, shrub, grass and crop association.

—*Indian Farming, Vol. VI, No.* 3, *dated March*, 1945.

MYSTERIES OF AUSTRALIAN TREES REVEALED

BY BANKS VON MUELLERINGHAM.

Being a brief Monograph for the enlightenment of New Arrivals to Australia,in the mysteries of Australian Trees:

The Englishman, the Frenchman, the German, have managed to keep their botanists reasonably in check. Even though botanists have attempted to make life a little difficult, they have merely achieved a partial success and have not gone beyond naming the Oak "Quercus" and the Pine "Pinus"—a thing which the ancient Romans had already done, anyway. In Australia, they found a marvellous field for their imagination, and have succeeded in making things really complicated for the new arrival. In this they were greatly assisted by several factors:

(1) Australia was originally inhabited by aborigines who gave aboriginal names to some trees. These names are in current use.

(2) Australia was discovered and populated (as the new arrival well knows) by English convicts, who gave English names to some trees. These names are in current use.

(3) Amongst the convicts there was a number of Irish rebels, who gave Irish names to some trees. These names are in current use.

To make things more interesting, botanists gave to all trees further names in Latin and Greek, being very careful *never* to use Latin or Greek on their own, but *always* both together, and never in such a way as to have any connection with the Aboriginal, English or Irish name.

For the information of the new arrival, nearly all the Australian trees, with the exception of wattles, mulga, hickory, gidgee, corkwood, stinkwood, bog onion, apple trees, hoop pines, bloodwood, cypress pines, beans, oaks, cedars, coachwood, sassafras, beech, rosewood, teak, ash, brush box, turpentine, and about fifty others, are Eucalyptus. The commonest of those are the Gums—Red Gum, so called because of its bluish-grey bark, and the Blue Gum and Grey Gum because of their red timber.

The late J. H. Maiden has recorded that a Blue Gum log brought to Sydney from the Hawkesbury, yielded 2,000 super. feet of timber.

The new arrival can safely apply the name of "Gum" to any tree with a smooth bark, and he will be always right, except in about 50 per cent. of cases. In these cases he will be referring to the smooth-barked apple, so called by the Irish because it does not yield either apples or apple blossom, does not look like an apple tree, and its leaves cannot be mistaken for those of an apple by the most elastic stretch of imagination. Not to be outdone, the English convicts promptly produced an apple tree of their own, as unlike in looks to the smooth-barked apple as could be found.

The new arrival will see trees with pine needles, which could be justly expected to be pines. He will be informed, however, that they are oaks, so called because acorns are as scarce on them as pine cones. The late J. H. Maiden had recorded that a She-Oak log brought to Sydney from the Hawkesbury, yielded 200 super. feet of timber. Just to make up for these pines that are oaks, the new arrival will be told of the Australian Cedar. And while he is looking for a Conifer, he will be reminded that it is April the 1st. The late J. H. Maiden has recorded that a Cedar log brought to Sydney from the Hawkesbury, yielded 20,000 super. feet of timber. It is not clear why the names of Spruce, Hemlock and Fir have not been applied to any of the Australian brushwoods.

There appears to have come a period when the Irish stopped naming trees. A sad time came when people without imagination gave the name of "Cypress Pine" to trees that in fact did resemble cypresses and pines. It appears that the rot had set in so badly that even botanists named a certain cypress pine "*Cupressiformis*", because it particularly resembled a cypress, thus making the whole show comprehensible. This was a most *Paddish thing to do. Strong measures* had to be taken.

And so, the botanists came back with a vengeance and gave a tree a Greek name, which, translated into English, means:

"IF-IT-HAD-ANY-PETALS-THEY-WOULD-LOOK-LIKE-HORNS-BUT-IT-HAS-NOT-GOT-ANY-PETALS".
(*Ceratopetalum Apetalum*).

They had named the trees thus because it does *not* look like a Christmas-bush. The convicts called it coachwood because of its usefulness for aeroplane construction. The late J. H. Maiden has recorded that a coachwood log brought to Sydney from the Hawkesbury yielded 20 super. feet of timber. There is no record, however, as to whether the cartage was paid according to November, 1942, Log Haulage Schedule. The botanists also gave the name of Casuarina to the She-Oaks, because there never has been any Casowary in the places where N.S.W. She-Oaks grow.

Lately, the Standards Association, or some such body, seems to have added its efforts to those of the Aborigines, the English, the Irish, and the Botanists. Colonial ruggedness is being replaced by civilised refinement and a Cypress Pine, which has been under the impression that it was a *Callitris robusta*, suddenly discovers that somebody has re-christened it into *Callitris glauca*. Even exotic trees, not *withstanding* that they cannot be planted without the express permission of the Minister, are not immune from rechristening, and what the late J. H. Maiden aptly described as "the everlasting *Pinus insignis* has suddenly become *radiata*. Incidentally, the late J. H. Maiden has not recorded that any *radiata* was ever brought to Sydney from the Hawkersbury.

And, anyway, as the sheep said to the shearer—"Eucalyptus".

—*The Bush Builder, November* 1945.

VOLUME 72 NUMBER 7

INDIAN FORESTER

JULY, 1946

THE VEGETATION OF THE THAR DESERT OF SIND

By A. L. Griffith, I.F.S.

(*Central Silviculturist, Forest Research Institute, Dehra Dun*).

In the May issue of the *Forester* I wrote a short note on an air reconnaissance of the Thar desert. As this area is so interesting and so seldom visited or described I have been asked to give some further details of it—hence this brief article compiled from my tour notes.

The Thar desert is the south western part of the Great Indian desert and is some 10,000 square miles in extent. It is bounded on the west by the Nara river, in the south by the Rann of Cutch, in the east by the Jodhpur continuation of the desert and in the north by other parts of the desert of Sind and Khairpur.

The Thar consists largely of sand hills which vary from small dunes to hills 300 or 400 feet high and which run in the general S.W./N.E. direction of the prevailing wind. These sand hill ridges are roughly parallel and about one half to one mile apart though in some places we find concentrations of dunes and hills with only a few hundred yards separating them. They are formed of sand which is blown from the Rann of Cutch by the monsoon winds which sometime attain a velocity of 40 m.p.h. and they overlie a layer of 6 to 12 feet of alluvium which in turn is over alternating layers of sandstone and sands in various stages of combination, calcium carbonate being the cementing medium.

These dunes or sand hills in the north of the desert where the wind velocity is considerably reduced are lower, further apart and in a transverse direction. The depth of sand is estimated at about 1,000 feet and it rests on some old rocks probably of the type found at Nagar Parkar (in the south east and bordering on the Rann of Cutch).

Along with the sand, millions of tiny sea shells and salt particles were also transported. In the course of time this calcareous material was dissolved and redeposited in the form of *kankar* and as saline concentrations. In parts, the sand became cemented giving rise to a soft sandstone. *Kankar* is more or less hard and where it occurs on the surface in quantity, as near Mithi, it is used for building purposes. Owing to these formations water occurs "perched" up at different levels where these impervious formations occur. We thus have two kinds of underground water, the deep seated water at about 600 to 1,000 feet, and occasional basins of perched water usually at about 100 to 300 feet.

It is a generally arid region with a rainfall of about 5 to 10 inches average and it is fairly close to the sea. There are no perennial rivers or streams. Rain water quickly percolates into the sand and disappears. A few water courses are shown on the map but these have a transitory existence usually only for a few hours during and after the rains.

The population density is about 15 to 30 to the square mile and the people raise a little rains *bajri* (*Pennisetum typhoideum*) in fields in the hollows between the sand hills. Occasionally they raise *juar* (cluster bean, *Cyamopsis psoraliodes*) and *mung* (green gram, *Phaseolus munga*) but that is about all.

The animals of the desert are very fine indeed and the camels are famed for their speed and beauty. Incidentally the Thar camel is the first I have met that I liked or wanted to pet, and one never sees a camel with its mouth muzzled to prevent its biting as one does in most parts of India. (*Fig. IV. plate 23*). The cattle and the sheep and goats are also very fine.

The vegetation is surprising in its density and variety. At the end of this article I include a list of the commoner species met with but in general, those that strike the eye are *Prosopis spicigera*, *Acacia senegal* and *Tecoma*

undulata all of which grow to quite big trees of 3 to 4 foot girth (*Plate* 22). Among the smaller trees are *Acacia Jacquemontii, Commiphora mukul* (prized for its gum) *Euphorbia neriifolia* and *Salvadora oleoides*.

The commonest shrubs are *Aerua tomentosa* (which in flower is a sea of white down used for stuffing pillows), *Calligonum polygonoides, Capparis aphylla* (used for fences). *Crotolaria burhia* (used for building huts), *Leptodenia spartium* and *Lycium barbarum* while on the ground are many herbs and grasses.

The grazing is excellent as is reflected by the condition of the animals. Some idea of the numbers of animals is shown by the following densities per square mile in one of the desert *taluks*, cattle 20, horse 1, sheep 10, goats 30, and camels 6. During the rains the desert blooms and many thousands of cattle come in for the grazing from the Indus valley. The animals are watered twice a day in puddled mud troughs and the water for them is pulled up from deep wells usually by camels. This water problem and the rains invasion of foreign cattle result in heavy local overgrazing and this in consequence has caused disappearance of the vegetation and locally has started on the move again sand that had been fixed for centuries.

The desert has many problems but quite the most important is control of grazing. There appears to be enough grazing for all if it is regulated and no need for the present locally severe wind erosion which is covering up fields and putting them out of cultivation and even endangering villages and towns. Bound up with this control of grazing is the forest problem of fuel and small timber for local use. There would appear to be little need to anticipate great difficulties for young growth of the more important species generally exists in fair quantities and it seems that simple protection would go a long way to a solution. It is quite unlike the other desert and semi-desert problems of the rest of Sind, the Punjab and the many Indian states that surround the Great Indian desert.

The Thar has quite low temperatures in the winter and frost is common, but the summer temperatures do not go unduly high although for a few months the sand bearing wind is said to be very difficult to live with. Even in the summer the nights are reasonably cool.

Mosquitoes and sand flies only appear in years of heavy rains and then only for a short time. The curse of the desert is the rats which are present in millions and are one of the great causes of erosion. Other animals seen were *chinkara* (the 4 horned antelope), fox, jackal, hare and near villages abundant pea fowl.

This is only a very brief outline of a very interesting and pleasant looking country of hills and dales. Literature about it is very scanty indeed, but for those who wish for further information the following articles are worth perusal. They have all been used in writing these notes and I make grateful acknowledgment of them. I append a list of the commoner plants met with. This was a joint compilation by us all and probably contains mistakes. I have to thank Mr. Raizada the systematic botanist of the F.R.I. for going through it and correcting the more obvious errors.

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A List of some of the commoner plants of the Thar desert area of Sind with local names as far as available.

Botanical name	Local name (Thar-Sind).
TREES	
1. *Acacia senegal*	.. *Kumbat, Khor.*
2. *Azadirachta indica*	.. *Neem.*
3. *Cordia rothii*	.. *Liar*
4. *Phoenix dactylifera*	.. *Khajji* (Date palm)
5. *Prosopis spicigera*	.. *Kahoor,* Kandi or Jhand
6. *Tecoma undulata*	.. *Roiro*

Fig. I

Typical scenery in the desert. Fields in the hollows between the sand hills. The tree growth on the hills is largely **Acacia senegal** and **Euphorbia neriifolia** while in the fields can be seen **Prosopis spicigera, Salvadora oleoides** and **Capparis aphylla**. The field crop is usually **bajri (Pennisetum typhoideum).**

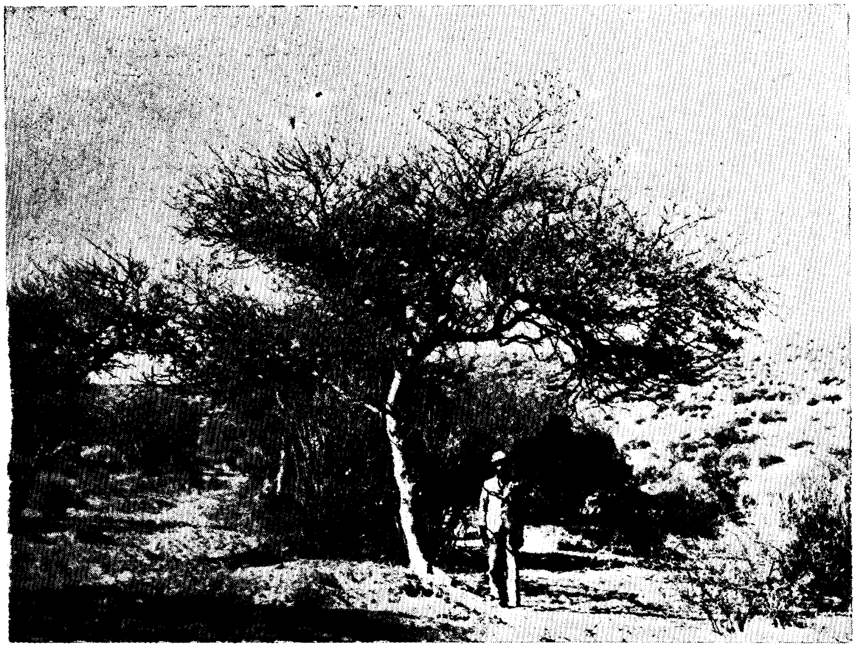
Photo: Author.

Fig. II

The desert will grow quite big trees if man allows it to do so. Large **Prosopis spicigera** trees are common in the fields in the valleys between the sand hills. They are 35 to 40 feet high and 3 to 6 feet girth.

Photo: Author.

Fig. III



Acacia senegal on the western aspect of a sand hill. It is about 25 feet high and 2 to 3 feet girth. This species is much more profuse on the western aspect than in the eastern aspect and is found on the sand hills and only rarely in the hollows. In places it regenerates itself profusely.

Photo: Author.

Fig. IV

The beginning of the day's journey. Riding camels at Naukot. The Thar camels are famed for their speed and beauty.

Photo: Author.

Botanical name		Local name (Thar-Sind).

SMALL TREES

1.	*Acacia jacquemontii*	..	*Bavuri*
2.	*Commiphora nukul*	..	*Gugul*
3.	*Euphorbia neriifolia*	..	*Thuhar*
4.	*Gymnososporia montana*	..	*Veenga*
5.	*Prosopis glandulosa*	..	*Devi-kandi*
6.	*Nannorrhops ritchieana*	..	*Farak* (Dwarf palm)
7.	*Salvadora oleoides*	..	*Jal*
8.	„ *persica*	..	*Jal*
9.	*Tamarix dioica*	..	*Lai*
10.	„ *gallica*	..	*Asri Asreli*

SHRUBS

1.	*Aerua tomentosa*	..	*Boo*
2.	*Alhagi camelorum*	..	*Kandera* (Camel thorn)
3.	*Bergia aestivosa*	..	*Reho*
4.	*Blepharis sindica*	..	*Bhengri*
5.	*Calligonum polygonoides*	..	*Phog*
6.	*Calotropis procera*	..	*Ak*
7.	*Capparis aphylla*	..	*Karir*
8.	*Cassia obtusa*	..	*Dhidusil*
9.	*Crotalaria burhia*	..	*Sinn*
10.	*Dipterygium glaucum*	..	*Thuma*
11.	*Fagonia cretica*	..	*Dramah*
12.	*Grewia populifolia*	..	*Gangheti*
13.	*Hibiscus micranthus*	..	..
14.	*Indigofera anabaptista*	..	*Chail*
15.	„ *semitrijuga*	..	*Sinjo*
16.	*Leptadenia spartium*	..	*Khip*
17.	*Lycium barbarum*	..	*Morari*
18.	*Pluchea lanceolata*	..	*Phaar*
19.	*Punica granatum*	..	*Anar* (Pomegranate)
20.	*Rhamnus persicus*	..	*Gharati*
21.	*Sericostoma pauciflorum*	..	*Kharsan*
22.	*Sida growioides*	..	*Baika-bhatia*
23.	*Supeda fruticosa*	..	*Lani, Arani*
24.	*Zizyphus nummularis*	..	*Kavkaur, Karkan*
25.	*Zygophyllum simplex*	..	*Lonk, Putlance*

Botanical name		Local name (Thar-Sind).

HERBS

1.	*Brassica campestris*	..	*Sarik.*
2.	*Citrullus colocynthis*	..	*Trui*
3.	*Cleome brachycarpa*	..	*Dharnkathori Sonalia*
4.	*Convolvulus microphyllus*	..	*Pat-kwar*
5.	„ *pluricaulis*	..	*Kiranj*
6.	*Corchorus antichorus*	..	*Munderi*
7.	*Cressa crotica*	..	*Oen, Orjin*
8.	*Cyamopsis psoralioides*	..	*Guar*
9.	*Farsetia hamiltonii*	..	*Lanteo*
10.	„ *jacuemontii*	..	*Hiran-chappadi*
11.	*Gnaphalium indicum*	..	*Kharsiya*
12.	*Gynandropsis pentaphylla*		*Bugra*
13.	*Helioptropium ovalifolium*		*Kunden*
14.	„ *scabrum*	..	*Kharzan*
15.	*Ipomaea chrysoides*	..	..
16.	*Justicia simplex*	..	*Janalo*
17.	*Launaea chondrilloides*	..	*Dhantar*
18.	„ *nudicaulis*	..	*Bhastri*
19.	*Melothria maderastatana*	..	*Aunkhro* (Climber)
20.	*Mollugo Hirta*	..	*Kunak*
21.	„ *nudicaulis*	..	*Hilrro*
22.	*Polygala byssinica*	..	*Harancha*
23.	*Portulaca oloracea*	..	*Lunak*
24.	*Pulicaria angustifolia*	..	*Phul-wal*
25.	*Tephrosia hookerlana*	..	*Vsan bishani*
26.	„ *tenuis*	..	..
27.	*Trianthema hydaspica*	..	*Lunak or Mamori*
28.	*Tribulus tomestris*	..	*Tricandi*
29.	*Typha elephantina*	..	*Pan*

GRASSES

1.	*Agrostis micrantha*	..	*Thari*
2.	*Cenchrus biflorus*	..	*Bharat*
3.	*Chloris virgata*	..	*Chabbar*
4.	*Cynodon dactylon*	..	*Kabb*
5.	*Cyperus arenarius*	..	*Chiya* (Sedge)
6.	„ *conglomeratus*	..	*Monia-chuhia* (Sedge)
7.	*Eleusine flagerlifera*	..	*Gandil*
8.	*Elionurus hirsutus*	..	*Senhi*
9.	*Eragrestis eiliaris*	..	*Lutia lamp*
10.	*Heleochlea dura*	..	*Dhokad*
11.	*Panicun antidetale*	..	*Gamol*
12.	*Sporobolus arabicus*	..	*Gamol, Banich*

OCCURRENCE OF HOPEA PARVIFLORA IN HANOVAR RANGE, WESTERN DIVISION, KANARA, BOMBAY PROVINCE—II.*

By S. S. Dhareshwar.

(*Assistant Conservator of Forests, Karwar*).

SUMMARY.—Several experiments of regeneration of *Hopea parviflora* undertaken have been described with the result achieved in each case.

Experiment I is in connection with shelterwood regeneration method and this has succeeded well.

Experiment II relates to interplanting in teak plantations of varying ages. This experiment failed to show satisfactory results.

Experiment III describes planting below 2 years old junglewood regrowth in felled coupes. This has succeeded admirably.

Experiment IV shows the result of transplanting in bare lateritic soil. This is also encouraging.

Germination of seed in shaded nurseries was not satisfactory perhaps owing to the loss of time in the transit of the seed. About three months old transplants succeed better than older seedlings. The writer advocates the method of treatment as described in Experiment I for promoting natural regeneration and transplanting under nurse crop as described in Experiment III for artificial regeneration of the species.

As outlined in the previous article, several experiments on regeneration of *Hopea parviflora* were undertaken. They are as follows:—

Experiment I.—*Tending natural regeneration:*

This was initiated with 6 parent trees of *Hopea parviflora* selected in March 1940 in Mahime forest on the Malemane Ghat alongside the Gersappa-Jog road. The elevation of the place is 1,120 feet above mean sea level and the forest is evergreen. The annual rainfall on the ghats may easily exceed 200 inches inasmuch as the coastal town of Honavar situated near the mouth of the river Shiravati about 25 miles west of the experimental area records an annual precipitation of about 150 inches. The soil in the forest is rich loam overlying granitic schist. Outcrops of quartz are not uncommon. The six trees selected were grouped under the three categories as already described *viz.*, (1) trees below which the natural recruitment was adequate (2) where it was moderate or poor but was likely to increase with improved conditions and (3) where it did not exist at all. The floor below the parent trees was cleared of the undergrowth and the ground cover to a desirable extent. The total area so cleared amounted to three-fourths of an acre. The understorey was raised to 30 ft. in three grades of intensity *viz.*, light, moderate and heavy, in order to admit light. The congestion in the top canopy was also removed just enough for the crowns of the parent trees to expand. The result of the operations was encouraging in that the self-sown seedlings got established without difficulty as otherwise they would have been choked and suppressed by the rank vegetation. The freeing of crowns of the parent trees gave them a stimulus to flower in abundance in March 1941.

The clearing was therefore extended in 1941 so as to involve 14 mother trees more in the same area. Thus the 20 trees were grouped under the three categories as described above. In all 163 junglewood trees of varying girth in the understorey were girdled to promote diffused light conditions, the side shade in each group being maintained. The understorey was now raised 40 to 45 feet and the weed growth on the floor was kept under control. The leaf litter in the plots was not, however, burnt. On the burst of the monsoon in June 1941, the seed on the floor began to germinate and by the end of September following some of the plots were carpeted with seedlings of *Hopea parviflora*. Along with these, there appeared also *Hopea wightiana* outnumbering the former and this phenomenon presented some difficulty in further weeding them out as *Hopea wightian*

* The previous article on the subject appeared in the *Indian Forester* for July 1940.

seedlings could not be easily distinguished from its cousin *parviflora* to which they bear great similarity.

The initial enumeration of the natural seedlings above 6 inches height and saplings as existed in the experimental plots when they were inaugurated was done in May 1941. The 8 plots which included the twenty parent trees were kept weeded and tended annually since 1941. The subsequent enumeration was done in May 1943 and 1945. The tabular *Statement I* appended (page 314) describes the plots and the natureof work done. The initial cost of formation of the 8 plots was Rs. 30/- per acre. The average annual cost of subsequent tending of the 2.25 acres during the following 3 years comes to Rs. 13 per acre. This expenditure could have been reduced to half as much, if it were not for the abnormalities created by war conditions. The total number of *Hopea parviflora* seedlings above 6 inches height as found in the six plots at the commencement of he experiment in the year 1941 was 396 per acre. In 1943 the average number of seedlings above 6 inches height established per acre in the 8 plots was increased to 1006. The number of the same kind of seedlings enumerated in May 1945 per acre was 1070. *Statement II* appended (page 315) shows the result of enumeration of the self-sown seedlings classified into 3 feet height classes.

The result of this experiment is encouraging and therefore continuing the tending operations annually for a full period of ten years in the present plots may be necessary before the floor under treatment is fully stocked with saplings large enough to withstand suppression. It may be noted that plot No. 8 which consisted of only one parent tree has had absolutely no seedling crop on the floor which (as in the case of other plots) was also cleared of the thick ground cover initially. Even after four years of maintenance this plot failed to have any seedling crop established. This may partly be due to the environmental conditions as the only parent tree in the plot stands completely isolated from its stock over three miles from the ghats which appears to be the habitat of the species and partly because of the insufficiency of the cleared floor which is 50 ft.$\times$50ft. The winged seeds might have been dispersed far and wide by the sea breeze which affects the place and thus the seed was lost in the dense undergrowth of *Strobilanthus* around the plot. The seeding of the species is also periodical and it may as well be that this tree has not yet seeded well. The clearing in this plot is therefore being extended in order to obtain a conclusive result. All the 8 plots were successfully fire-protected.

The idea underlying this experiment is to help the natural regeneration to establish itself and compete successfully in the struggle for existence so that the species can multiply easily in its own environment inasmuch as the artificial regeneration of the species is rather difficult and gives uncertain results except under very favourable conditions. The sporadic groups of *Hopea parviflora* as they occur now can thus be gradually extended under this shelterwood regeneration system and the species established over wider areas. The guiding principle is to raise the midstorey gradually from below and to so manipulate the top canopy as to stimulate the parent trees to expand their crowns and seed in abundance. These operations enable the recruitment to grow without encouraging a thick growth of fast growing inferior species which otherwise invade the areas where excessive light has been admitted. Some of the fast growing species may even serve as nurses and therefore their presence to some extent in the undergrowth should not be discouraging.

The future method of treatment should therefore comprehend the selection of parent trees, 8 ft. and up in breast height girth, for being involved in the tending operations. The sequence of operations may spread over 5 to 10 years as shown below between the establishment of seedlings and the final felling of the parent tree as it is not possible to work to a strict schedule inasmuch as the species seeds but periodically. The following schedule is suggested:—

1st year.—Laying out plots. Girdling of unwanted species to raise the midstorey. Freeing of crowns of parent trees. Cleaning the floor. Enumeration of recruitment already present.

2nd Year.—Regirdling if necessary and cleaning.

3rd Year.—Cleaning and enumeration.

4th Year.—Cleaning.

5th Year.—Cleaning and enumeration.

6th Year.—Cleaning.

7th Year.—Cleaning and enumeration.

8th Year.—Felling of mother trees and cleaning. Exploit the timber.

9th Year.—cleaning and enumeration.

10th Year.—Thinning and cleaning and enumeration.

Note.—It is not economical to extract fuel wood from the ghat forests. It is therefore to be removed away from the plots.

Artificial Regeneration

EXPERIMENT II.—*Interplanting in teak plantations.*

Self-sown seedlings of *Hopea parviflora* about one year old obtained from Malemane ghat forest and interplanted since the year 1941 in Honavar range in congenial situations in teak plantations of ages 4, 6, 10, 17 and 21 years survived to the extent of 47 to 80 per cent. at the end of the first year. The casualties increased in the 2nd year in the older plantations especially 6 years and above in age so much so that the survivals dwindled to about 5 to 10 per cent. at the end of the 2nd year and failed ultimately in the 3rd year. Obviously the transplants could not withstand the heavy drip from teak leaves. So this experiment was abandoned.

EXPERIMENT III.—*Planting below 2 years old coppice.*

Three to ten-months old self-sown *Hopea parviflora* seedlings were transplanted under the two-year old bushy junglewood regrowth in clearfelled and regenerated fuel coupe No. 11 in block XI of Mahime in Honavar range which originally consisted of semi-evergreen stand. The planting was done in the year 1941 June. The result as shown in the tabular statement below has been quite satisfactory as the coppice served as a nurse to the young *Hopea* transplants which were tended annually and freed from suppression by the nurse plants. The number of transplants put in initially was 150 under suitable bushes. They were mulched and staked.

Date of Enumeration	No. of seedlings in 3 ft. height classes							
	Below 3 ft.	3 ft. to under 6 ft.	6 ft. to under 9 ft.	9 ft. to under 12 ft.	12 ft. to under 15 ft.	15 ft. to under 18 ft.	Above 18 ft.	Total.
13th March, 1942 ..	78	26	1	1	..	..	..	106
6th May, 1944 ..	40	32	15	5	2	1	..	95
23rd August, 1945 ..	24	20	19	13	10	1	1	88

Thus the survivals after four years tending number about 59 per cent. The minimum height of the plants is 1 foot, the maximum is 19 ft. 6 in. and the average is 6 ft. 9 in. No expenditure was incurred as the planting and tending work was done by guards. The fire protection was successful throughout. The result is remarkable in that *Hopea parviflora* is very refractory to artificial regeneration. This method of artificial regeneration under shady bushes of regrowth in exploited coupes is found to be one of the best and cheapest while compared to the more laborious and expensive method of raising the species under a nurse crop like *Tephrosia candida* also specially cultivated. The only disadvantage is that a regular spacing cannot be maintained. And yet the method is commended as it is meant to supplement the natural regeneration of junglewoods in only such parts of the exploited coupes as are found congenial to a hygrophilous species like *Hopea parviflora.*

EXPERIMENT IV. *Transplanting in bare lateritic soil.*

When the writer of this note visited the countryside near Coondapoor in south Kanara in the year 1938, he was surprised to find *Hopea parviflora* growing either solitary or in groups on lateritic soil in open conditions and in private gardens. He got some mature seeds and some seedlings to try them in a similar locality near about Honavar. A small area on bare lateritic soil well drained, near Anilgod forest quarters was selected in June 1938 and 20 one-year old transplants were put in. The seed was sown in a shaded nursery which was irrigated when there was a break in the rains. The transplants were spaced about 20 ft. The plot was enclosed by a live hedge of *Euphorbia tirucalli.* The 20 plants thrived well during

the monsoon, but they showed signs of withering in the following hot weather whereupon watering was started every alternate day from March to June 1939. Nineteen of them survived the hot season and have been progressing well ever since. Watering in summer from the second season was stopped. Excepting an accidental damage to the leading shoots of a few of the plants done by a stray bullock that broke through the fence in 1941, the plants did not have a setback.

The nursery gave very poor results and only about 30 seedlings which it yielded were transplanted in the aforesaid enclosure. The height growth recorded gives the following result:

Date of enumeration	Below 3 ft.	3 ft. to under 6 ft.	6 ft. to under 9 ft.	9 ft. to under 12 ft.	Total	REMARKS
17th March, 1944 ..	14	8	6	2	30	Survivals are 60 per cent.

The maximum height of the plants is 12 ft. minimum is $3\frac{1}{2}$ ft. and the average is 6 ft. The growth is slower in this plot inasmuch as the conditions are open here and the soil poor. No expenditure was incurred on account of this small experiment as the works were carried out from time to time by the guards living in the adjacent quarters. The area was fire-protected successfully. This experiment indicates that with some care *Hopea parviflora* can be propagated on lateritic soil which has the capacity to retain moisture during the hot weather.

Conclusion :

Although the Experiments III and IV were undertaken on a small scale, they have been convincing enough to show that *Hopea parviflora* though a hygrophilous species growing in a deep rich soil in the evergreen forest can adapt itself even down to a lateritic soil in open conditions, provided the rainfall and climate be favourable. It can therefore be propagated without much difficulty in the moist mixed deciduous type of forests of the foothills in this western division, Kanara.

Transplanting required a good deal of care and regeneration by this method is difficult as the seedlings have long woody tap roots which break in uprooting them. Seeds put in nurseries do not readily germinate. Nevertheless, some success can be achieved in transplanting when seedlings of 2 to 3 months age are used. Dibbling is a better method where the mature seed can be collected and transmitted easily and quickly. To promote establishment of the natural recruitment, the following details of tending work are the optimum that should be attended to: (1) Reduction of ground cover to reduce the toxic effects in the top soil and facilitate germination soon after the seedfall. Good aeration dissipates the toxic substance. (2) Freeing crowns of the parent trees. (3) Gradual raising of the midstorey to admit diffused light to stimulate the growth of the natural recruitment. (4) Retaining side shade. (5) Effective fire protection as the species is hygrophilous and also fire tender.

It is observed that *Hopea parviflora* is rendered sporadic inasmuch as a large number of other species compete with it in nature and create conditions adverse to gregarious growth. But the environmental conditions can definitely be changed as indicated above under Experiment I so as to make the species gregarious in habit.

(*Concluded.*)

STATEMENT I.

EXPERIMENT I.

Abstract of work done in the 8 experimental shelterwood regeneration plots in Mahime forest on Malemane slopes in Honavar range.

Experimental plot No. and size of the plot.	Serial No. of parent trees involved and girth at B. H.	Category to which the plot belonged.*	Condition of natural recruitment below 6 inches found initially.	Height to which the understorey was raised in : 1941	Height to which the understorey was raised in : 1944	Total No. of seedlings above 6 inches as counted in : May 1941	May 1943	May 1945
	Ft. Ins.			Ft.	Ft.			
(1) 90 ft. by 75 ft. ..	1. 5 2 2. 4 6	I	Abundant	30 heavy	45	64	502	691
(2) 160 ft. by 140 ft.	3. 10 3 4. 3 1 5. 4 2 6. 4 3	I	Do. ..	30 heavy	45	127	814	670
(3) 125 ft. by 150 ft.	7. 11 8 8. 3 6	II	Moderate ..	30 Moderate	40	47	329	244
(4) 140 ft. by 125 ft.	9. 3 11 10. 4 1	III	Poor ..	25 Light	45	6	106	62
(5) 150 ft. by 125 ft.	11. 5 8 12. 3 11 13. 3 9 14. 3 11	II	Moderate ..	25 Light	45	19	89	150
(6) 150 ft. by 60 ft.	15. 4 3 16. 4 6 17. 3 11 18. 2 11	I	Abundant ..	30 heavy	45	27	363	549
(7) 50 ft. by 50 ft. ..	19. 7 4	III	Fair ..	30 Moderate	45	7	61	40
(8) 50 ft. by 50 ft. ..	20. 5 2	III	Nil ..	30 heavy	40	..	..	..

*Category I.—Trees below which the natural recruitment was adequate.

*Category II.—N. R. was moderate but likely to increase with tending.

*Category III.—N. R. was poor or nonexistent.

For the purpose of this experiment seedlings above 6 inches height are considered as established.

Total area covered by the 8 plots measures 2·25 acres. The initial cost of formation of the plots was Rs. 30 per acre. The average annual cost of tending amounts to Rs. 13 per acre. The average number of seedlings above 6 inches height found initially per acre was 396. In 1945 that is after 4 years of tending the saplings and seedlings above 6 inches height averaged 1,070 per acre. Thus the cost of establishing 1,070 saplings and seedlings was Rs. 69 in four years.

STATEMENT II.

EXPERIMENT I.

Result of enumeration of selfsown seedlings of *Hopea parviflora* tended in the experimental shelterwood regeneration plots in Mahime forest on the Malemane slopes in Honavar range.

PLOT NO. / No. of mother trees in the plot.	NUMBER OF SEEDLINGS OF HEIGHT CLASS						Date of enumeration.	Present height of under-storey in feet.
	Up to 6 inches	Over 6 in. to 3 ft.	Over 3 ft. to 6 ft.	Over 6 ft. to 9 ft.	Over 9 ft.	Total.		
I	..	51	8	5	..	64	30-5-1941	45
	250	495	5	2	..	752	13-5-1943	
2	31	642	40	4	5	722	14-5-1945	
II	..	60	40	27	..	127	30-5-1941	45
	275	685	95	30	4	1,089	13-5-1943	
4	18	541	103	15	11	688	14-5-1945	
III	..	32	13	2	..	47	30-5-1941	40
	110	225	97	5	2	439	13-5-1943	
2	71	186	52	3	3	315	14-5-1945	
IV	..	2	1	3	..	6	30-5-1941	45
	25	102	1	1	2	131	13-5-1943	
2	..	53	6	1	2	62	14-5-1945	
V	..	2	6	11	..	19	30-5-1941	45
	80	70	13	2	4	169	13-5-1943	
4	18	130	11	4	5	168	14-5-1945	
VI	..	24	2	1	..	27	30-5-1941	45
	90	360	..	..	3	453	13-5-1943	
4	13	519	25	3	2	562	14-5-1945	
VII	..	1	1	5	..	7	30-5-1941	45
	30	25	1	3	2	61	13-5-1943	
1	..	32	3	1	4	40	14-5-1945	
VIII	..	..	..	..	..	..	30-5-1941	40
	..	..	..	..	..	..	13-5-1943	
1	..	..	..	..	..	..	14-5-1945	

NOTE.—Natural recruitment below 6 inches height was not enumerated initially on 30-5-1941. But there was general flowering of the parent trees in that year after freeing the crowns and none of the kind occurred up to 1945.

Plot No. VIII is far removed from the ghats and is nearer to Gersappa and subject to sea breezes. The parent tree included in the plot is isolated from its kind. No natural recruitment was existing at the beginning and the condiition has remained unchanged ever since 1941. Possible reasons for its failure to reproduce have been stated in the body of the article.

THE PROBLEM OF SOIL EROSION ALONG THE JAMNA AND CHAMBAL RAVINES IN THE UNITED PROVINCES, ESPECIALLY IN ETAWAH DISTRICT

By K. D. Joshi, I.F.S.

(*Deputy Conservator of Forests, Naini Tal Forest Division*)

Of all the post war problems in the United Provinces one that must be given priority is the solution of the acute situation that the constant and serious erosion of their banks by the Jamna and the Chambal rivers has caused to the adjoining country. Not only the banks have been eroded for a considerable distance on either side but the deep gullies caused are eating into the cultivation sometimes as far as two miles inland. In the Etawah district where the Jamna and the Chambal join, the land in between has been left in a precarious condition due to erosion from either of the two rivers (*vide Figs. I and II, plate* 24).

The Jamna river rises from the Himalayas and after taking a more or less perpendicular direction to the Himalayan range running north and south, due to the Aravalli Hills near Delhi and later due to the hard *Kankar* (calcareous deposits) diverts suddenly to the east and makes a serpentine and tortuous course through the hard calcareous soil up to the Cawnpore district. Thereafter it takes its normal course until it meets the Ganges at Allahabad.

The Chambal river on the other hand takes its rise from Central India from a place near Indore and after running north and north-east to the Indo-Gangetic plain, meets again this hard calcareous soil as the Jamna does, flowing thereafter eastwards more or less parallel with the Jamna river until it meets it at Bawain in the Etawah district.

The erosion of the soil naturally starts when the two rivers begin to cut through the hard calcareous soil on their way through the southern portion of U.P. In making their way through this hard soil, the rivers have made deeper channels leaving high banks on either side. When the rivers are in spate during the monsoon, the various creeks formed due to erosion of the soil on either side get filled up with the overflow of water and when the floods recede later they take away all the soil with them making the ravines deeper and deeper and the banks more precipitous every year. Thousands of tons of good soil are thus carried away downstream every year giving rise to silting and flooding down in Bihar and Bengal adding to the problems of these two provinces.

It is not attempted in this short note to give the various causes that have given rise to the formation of ravines but the two main causes that are apparent are given below:

One of them is the rapid destruction of the vegetation on either bank of these two rivers and the uncontrolled grazing and severe browsing by goats and camels of the little growth that is left. The soil by these two actions is left without any cover resulting obviously in more and more erosion (*vide Figs.* III and IV, plate 24).

The other cause that is lost sight of is the pressure of the population and the increasing cultivation on either side. Along the slopes any loosening of the soil that is caused by constant ploughing by the villagers to grow their food crops, adds to the denudation.

These two causes of sheet erosion and gully erosion have a combined action and the ravines and gully formation are therefore yearly on the increase.

The problem now therefore is to give a check at least to these two main causes.

The obvious solution to cause No. 1 is by checking the destruction of vegetation and controlling the unrestricted grazing by animals and browsing by goats and camels. The forest department wisely understood this problem and with the initiative of Sir John Hewett (late Lt.-Governor of U.P.) assisted by Messrs. P. H. Clutterbuck (later Sir Peter Clutterbuck), Nevil, I.C.S., Courthope, I.F.S., took up the much needed afforestation policy in 1912. A compromise was arrived at between the three schemes, *i.e.* (1) Ravine reclamation to prevent further erosion, (2) the creation of fuel and fodder reserves for the local villages and (3) a financial scheme for obtaining a profitable return from waste lands. In order to

Fig. I

Deeply eroded valley of the Jamna river with only **karil (Capparis aphylla)** growth on the foreground to contrast with well wooded Fisher forest in the background.

Fig. II

The Jamna river ferry at Kalpi with the eroded hillocks on the Sky-line

Fig. III

Badly lopped **Nim (Melia indica)** avenue on Etawah-Fatehgarh Road.

Fig. IV

Badly lopped **Babul (Acacia arabica)** along the Canal Bank.

Fig. V

Sissu plantation 3 years old after 1st thinning along Canal Bank.

Fig. VI

Three years old **Chir** pine (**Pinus longifolia**) transplanted in inverted pots ready for putting out in the forest in South Kheri Dn., Lakhimpur Kheri.

Fig. VII

Chir pine (**Pinus longifolia**) introduced, growing in Canal Inspection House, Sikndra Rao Aligarh Canal Division, I Circle.

Fig. VIII

Babul (**Acacia arabica**, var., **Cupressiformis**) 2 years old at Etawah.

achieve the object arrived at, some local *zamindars* (land owners) of Etawah district placed parts of their lands at the disposal of the forest department to form into forest blocks. These blocks were chosen at distances to form nuclii for further expansion, should the afforestation policy succeed. These forest blocks were then protected against indiscriminate felling and grazing and were brought under a regular scheme of afforestation. After a few years or to be exact in 1928, it was found that the hard calcareous pan underneath prevented the growth of trees. The policy of growing trees was therefore abandoned to be replaced by a policy of controlled grazing. This is being followed now.

The result of this policy has been the complete stoppage of erosion from these forest blocks and the serious problem of checking erosion has now been solved for ever. When the afforestation work was proceeding in order to give aid to the work, banking of the deeper depressions and gully plugging were also done which resulted in arresting any undue erosion along these depressions and the tree growth (which by the way is excellent along these depressions) further helped in binding the soil (*vide plate* 25).

Cause No. 2 however has not been taken up in any satisfactory manner. Indiscriminate increase of land under cultivation along the slopes is still the custom everywhere and with the new policy of 'Grow more food' campaign, additional stimulus has been given to the cultivators to bring even indifferent soils under plough. Had this cultivation been regulated by proper *bunding* of the ravines and by proper terracing of the fields, probably erosion may not have been so great along the cultivated areas.

The only solution that appears to be obvious is that of closing these areas for some distance on either bank of the Jamna and Chambal ravines to reckless cutting of tree growth and other vegetation and the indiscriminate grazing by cattle. Propaganda has to be done in the villages to show them that closure of these areas would give them better chances of securing fuel and fodder for their needs. The prevalent idea that closure means an end to all their fuel and grazing needs should be proved how fallacious it is in their own interests.

As stated above unless proper *bunding* of the ravines and terracing of the fields is resorted to, both being expensive items and beyond the means of the ordinary cultivator, cultivation for some distance on either side of the rivers must be stopped forthwith.

At this stage it is considered impossible to *bund* so many ravines and smaller depressions scattered over the district and the only cheap and easy method of stopping erosion is by closing these areas and creating them into fuel and fodder reserves under the management of experts. Terracing of fields may be possible but this requires constant attention. With the *Kankar* (calcareous) pan underneath and the shallow and poor nature of the soil available for cultivation, this terracing will prove uneconomical to the cultivators in the long run and the other easier method is therefore obvious and is advocated.

ORGANISATION OF CO-OPERATIVE CHO RECLAMATION SOCIETIES*

By Sardar Sahib Balwant Singh, P.F.S.

Object

The main object of the formation of these societies is to manage village waste lands in the best possible manner so as to produce timber, fuel and fodder for the domestic and agricultural requirements of the rightholders and maximum revenue from the sale of surplus forest produce.

Formation

An application from the rightholders of an area is first secured. A list of shareholders is prepared, working out the share of each member. All prescribed registers are started. Office bearers are elected. The society is then registered. They are classified as A, B, C, according to efficiency of their working. Bad

*Paper presented at the Soil Conservation Circle Officers Conference, Punjab, held at Hoshiarpur on 19th to 21st November 1945.

societies are classified as D. Out of 197 societies registered in Hoshiarpur district 11 are A class, 30 B, 95 C and 61 unclassed being new, but there are no D class.

Closures

An application for the closure of the area under section 38 Indian Forest Act or Land Preservation (Chos) Act is secured. The co-operative department believes and holds that application under section 38 Indian Forest Act is more suitable. On account of flexibility of the rules it can satisfy the demands of people better. There is no rigidity about it. Democratic principles on which these institutions are based are met with better under forest act. People are in favour of employing their own *rakhas* (or guards) in preference to outsiders. A forest guard or forester acting as a block officer has 3—8 societies under him.

The area is demarcated and closure papers are prepared by *patwaris* deputed for this work by the revenue department. There are at present 4 such *patwaris* working in Hoshiarpur district. 2 blocks are formed. Block A in which neither cutting of the trees nor grass etc. is permitted without the permission of the divisional forest officer. It is equivalent to section 5 of Chos Act. Block B where browsers are eliminated but cattle grazing is permitted. Trees are cut with the permission of society for the *bonafide* domestic and agricultural use of the rightholders; it is equivalent to section 4 of Chos Act.

Management of the Society

The protection of the area is done through the *rakha* appointed by the society with the approval of the divisional forest officer. The recovery of compensation and prosecution of offenders is done by forest department. The auction of forest produce, distribution of income to the members and auditing of accounts is done by the co-operative department through their local sub-inspector. From the income a reserve fund of one per cent. land improvement fund $7\frac{1}{2}$ per cent, and common good fund $7\frac{1}{2}$ per cent. are usually created and rest of the money is distributed to the members in accordance with their shares in the land. Works of improvement are carried out under the supervision of forest staff assisted by co-operative staff. Sowing and planting of useful species is undertaken. Streams are so trained as to make village habitations, cultivated fields, and *shamilat* areas safe from the action of the *chos*. Areas reclaimed from the bed of the streams are sown or planted with useful trees in order to meet timber, fuel and fodder requirements of the community. Sloping lands are terraced and watted with a view to check runoff and soil wash.

Working Plan

Soon after an area is notified it is necessary that a working plan or scheme should be drawn up so that works of improvement be not delayed. But the rate at which societies can be formed is limited by lack of staff, and it is impossible to keep pace with preparation of plans or schemes if a separate one for each village be drawn up. It is therefore, suggested that for a group of societies in a particular tract or on a particular stream or group of streams, a plan be drawn up. All works to be carried out in the group should be laid down as the prescriptions of such a plan. To expedite the preparation of such plans a draft plan, duly approved by the conservator for each type of area can be adopted. The prescriptions as regards silvicultural system, object of management, rotation, felling cycle, felling rules, species best suited for sowing and planting and their introduction for each type of forest will have to be laid down. The same shall remain a constant factor for the whole area of similar type. Programme of sowing, planting, weeding, cleaning, thinnings and fellings will have to be filled up. Writing a separate plan for each society can thereby be eliminated and yet a programme of all types of work to be carried out will be given in the master plan. For this purpose it is essential that societies should be formed in particular areas where concentrated working should be possible. Thus formation of societies in groups of villages adjoining each other should be the guiding principle. The fact that we have to accept societies wherever they are formed is apt to make a patch-work distribution and too wide a distribution of our energies and staff.

Sowing and Planting and Cho Training Works

There is a growing tendency that the works should be carried out through labour engaged on daily labour. Part of the money spent is paid by government and the rest by the society. In this manner the works which

could be carried out without any cost by the owners themselves are also done on payment of wages and thus prove expensive in the long run. It would be preferable if owners were to be infused with the spirit of carrying out works with their own hands so that income which they derive from the society may not be spent on works. Planting and *wattbandi* weeks can be organised in which staff of both forest and co-operative departments can help in supervising such works. School children should be interested in growing trees for the supply of timber, fuel and fodder in village waste and creating school forests in the land adjoining the school building.

Wattbandi

Although cultivated fields rarely form part of the area managed through societies yet their improvement deserves attention at the hands of the society. *Maliks* (owners) and occupancy tenants, if guided properly, do pay attention to this important work; but tenants at will do not show the least interest. Their interest can only be invoked if certain concessions from *maliks* can be obtained in their favour in the form of reduction in the share of produce which they have to pay for a fixed number of years and/or securing a tenure of 5—10 years instead of the usual one year lease. As terracing and *wattbandi* of cultivated fields is in no way less important than conservation of forests, it is urged that societies should pay special attention to this important matter. *Wattbandi* societies are being organised, but the multiplication of single purpose societies is to be discouraged and instead all kindred activities are to be handled by the one society.

Co-operation between Revenue, Forest, Co-operative and Agricultural Departments

Thorough co-operation between the revenue, forests, co-operative and agricultural departments is necessary if the best results are to be achieved. Hoshiarpur has been very lucky in securing complete co-operation between officers, but similar complete co-operation between subordinate staff of all departments is yet to be attained.

Defects

Although there has been a complete co-operation between the forest and co-operative departments in organization and management of societies there are certain defects in the working which need mention here. The same are detailed below:

(*a*) *Rakhas*.—Their early appointment soon after the issue of the notification is necessary. Low paid, part-time *rakhas* cannot protect the area efficiently. Instead whole-time well paid *rakhas* for groups of societies would be more suitable.

(*b*) *Produce from maurusi* (*tenant*) *land*.—With the consent of the owners *maurusi* lands are also closed under section 38 Indian Forest Act. But *maurusi* tenants are entitled to the produce with the consent of the society only. Such permission is sometimes refused. Wherever the tenants prefer to cut grass or remove other produce for their own use the same should be permitted instead of selling it with the rest of the area, owned by owners.

(*c*) *Closures*.—Instead of forming a society for the waste land of the whole of the village, a small fraction is taken under control and a society formed. Although the number of the societies is thereby increased the control of the rest of the area involves great difficulty and consent of the people is not easy to obtain later. It is therefore, preferable to form societies for the management of the whole of the area instead of part.

Revenue *patwaris* deputed for the preparation of the cases are usually sent to us as a punishment. Their work is slow and many villages remain untouched for a long period after the application is secured. It would be preferable if *patwaris* be appointed directly by the co-operative department or work of the demarcation and preparation of closure cases be entrusted to forest department. In the latter case a group of *patwaris* shall have to be engaged with the permission of the conservator for works of societies only.

(*d*) *Demarcation*.—Construction of pillars is usually delayed particularly where income of the society in the beginning is low. It would be preferable if a loan be granted to such societies for the construction of pillars which should be recoverable from the income later on. Construction of pillars at an early date, soon after the notification is gazetted, is necessary in the interest of proper protection.

(*e*) *Compensation*.—The co-operative department prefers to recover compensation from members directly under bylaws of the societies. Is there any objection to it? Legal position as regards recovery of compensation

is that it should be recovered and remitted into the treasury first and then paid to the society in the form of grant in aid.

(*f*) *Staff.*—Separate foresters and deputy rangers and forest guards should be appointed to supervise the work of the society's *rakha* and recover compensation from the societies. At least one forester and a suitable number of forest guards in each range should be appointed. The range officer should make notes of inspections in the society's register.

(*g*) *Distribution of share money.*—People demand early distribution of income of money to shareholders. In certain cases it is delayed. Such delays should be obviated. Nurseries should be formed as early as possible and if this expenditure is heavy a grant in aid should be given.

(*h*) *Sale of Produce.*—Auctions are usually held by the sub-inspectors. All of them are not well versed in framing rules. Date of auction should be fixed well in advance and advertised in the locality. Rules should preferably be framed with the help of range officer and auctions held in a central place for groups of societies as far as possible, so that competition between the purchasers can be created. Auctions should preferably be attended by range officers or block officers in addition to sub-inspectors. It would mean extra work for the range officer but if through his guidance societies can make more income it is surely worthwhile.

EXTRACTS

FOREST ORNITHOLOGY (SOME MEDITATIONS) *

BY J. M. D. MACKENZIE, F.Z.S., M.B.O.U.

I have always been interested in birds, so when I went as a student to Darmstadt, under Forstmeister Kuhlmann, who had been sent by his government to Seebach to learn von Berlepsch's methods, we discussed those methods, and I got an early start in Forest Ornithology, or Forstvogelschutz. Birds were one of my hobbies in Burma, but the jungles were too vast to allow of anything being done to help them. A recent article by Mr. W. L. Taylor, C.B.E. (5), interested me greatly, and I venture to give below some impressions and ideas, the result of a good many years of sporadic thought.

Forest Ornithology has nothing to do with rarities. It is rather the very detailed study

* Many of the ideas embodied in this article were first given by the author in his article on forest insectpests in Burma, which appeared in the *Indian Forester*, Vol. XLVII, No. 8, dated August 1921, pp. 309—317.—*Hon. Ed.*

of the habits of our common woodland birds, (first) to decide whether they are beneficial or not, and (second) to use the habits of desireable species so that we can get them where and when we want them, in the most suitable numbers. Taylor has shown (5) that by the provision of suitable nesting sites, in this case boxes, a bird can be induced to nest where it did not nest before. The Pied Flycatcher became the most numerous species using the boxes set up in the Forestry Commission's experimental plots in the Forest of Dean; from being unknown locally as breeders, they became the tenants of half or more of the total number of boxes used. So we may be concerned with species potentially as well as actually common.

Many men have studied birds in an endeavour to decide whether they are useful or not, and we have a considerable amount of data about their diets. But these investigations have usually been undertaken in the interest of agriculture, including fruit growing, and so specimens have mostly been taken from agricultural land. As a general principle, most of the higher animals eat a type of food rather than particular species, that is a bird eats, *e.g.*, larvae, and small Coleoptera and Lepedoptera, wherever it is, the exact species depending on what it finds. So to get a true picture of what a bird eats in woods, one has to use specimens taken in woods, and not in fields. With the information at our disposal from agricultural and fruit garden analyses, the number of specimens wanted is not very great, just enough to see what birds and nestlings taken in fairly extensive woods do in fact eat. Collinge, (2) P. 148, in discussing the variations in the food of the blackbird in urban and fruit growing districts says "A bird feeds on the food which is most easily obtained." This applies to differences in the details of food in forests and fields also.

Care is wanted in interpreting remarks about food. The Dipper is stated to eat "32·5 of injurious insects." But these are such things as dragonfly and water-beetle larvae which prey on trout ova, etc. This is an obvious case, and so are birds like the Skylark and Lapwing, which do not live in woods. But others, like the Blackbird, are not so simple. Where fruit is grown, it is a really bad pest. But when found in big areas of woods, the 23% injurious insects which it consumes in urban districts is probably increased, and the only damage it can do is to eat tree seeds and fruits, which are of no importance in most woods. In smaller woods surrounded by agricultural land where fruit is not a main crop, the good it does probably exceeds the harm, but it is a matter for decision in each individual case. The nests in woods are easy to find and destroy if one wants to reduce the numbers.

A point often missed is that almost without exception nestlings are fed on a diet which is mainly if not entirey animal food, and during that period adults eat much the same food as their nestlings. Collinge (2), p. 39, gives examples of the percentage of insect food in the nestling diet :—Linnet, Skylark, Chaffinch, Blue Tit, Yellow Bunting and Wren, 100%, Song Thrush, 96%, Starling, House Sparrow and Great Tit, 90%, Missel Thrush, 74%, and Blackbird, 60%. In the last two birds, the remainder of their food is animal matter, mostly worms and slugs, and in none of them is there more than 4·5% of vegetable matter (House Sparrow). Even the Greenfinch and Bullfinch eat a considerable number of insects as nestlings. This is really what one would expect. During the winter, numbers of birds have been feeding on the available store of seeds, berries, etc., and by March and April, the stock of this type of food is low, while what is left is germinating, and fresh shoots and seedlings are a poor substitute for the concentrated food in the seeds. Co-incident with this, there is a heavy drain on the hens in laying eggs and later in feeding their nestlings, which eat, for their size, enormous quantities of food, variously given as from half to more than their own weight a day. The demand at this time is also more for protein and less for fats and carbohydrates than during the rest of the year. Luckily for the birds insect eggs are hatching at this period, and the larvae, which mostly feed on vegetation in one form or another grow quicky; hibernating insects, which have been hidden through the winter once more move about after food and become vulnerable, and insects emerge from their pupae as imagines. So just at the time when there is a scarcity of seeds and fruits, combined with a demand for extra, food especially protien food, a good supply becomes available and is used by a seasonal change in feeding habits. Insect food consumed at this time contains a very low percentage of beneficial insects.

In considering the value of a bird which eats mainly insects as a nestling, and other foods when adult, there are two important points.

As a nestling, and while growing, a bird eats very large quantities of food for its size. Collinge (2), p. 124, gives an estimate of between 7,000 and 8,000 insects eaten in the nestling period by a pair of Great Tits and their progeny. The nestling period is about 20 days. Very much the same kind of figures apply to *e.g.* the Chaffinch, which feeds on other foods after leaving the nest.

The mortality amongst birds in the period just after leaving the nest is very high. I have no figures, but put it at about 50% in the first three months, from such experience as I have with ringing nestlings. They meet with all sorts of accidents from cats, etc., and nowa days cars kill a number on the roads. Therefore, the number of birds feeding on the beneficial nestling diet is considerably higher, perhaps double the number feeding on the less beneficial, and possibly partly injurious adult diet. (A difficulty about the expression of ideas comes in: A diet is beneficial when it consists of injurious insects, and vice versa). What this means in rough figures is that while 100 birds (the adults eat the same as nestlings at this time) eat an insect diet consisting mainly of injurious insects, at a time when their appetites are very big, only 50 or perhaps 60, allowing for adults, eat the less beneficial adult diet during the rest of the year. This number becomes progressively less till the next breeding season, when they revert to a beneficial diet.

It has proved impossible to exterminate insectpests ever in fruit gardens, where, in addition to birds, various intensive methods such as spraying and banding can be used. Nor perhaps is it desirable to do so, as insects help to fertilise the blossom. The balance seems to be that insects live in the tree and fertilise it, while brids also live in the tree, and keep the insects from becoming numerous enough to destroy their common habitat. There is another control, parasites and predators, Ichneumons, Chalcids, Braconids, Carabids, lady-birds, etc. Birds are not interested in what species they eat, unless it is distasteful, when they leave it alone, and the numbers of useful insects taken is probably in the same proportion to injurious as that in which these insects occur. If this is correct, birds diminish the numbers of injurious and beneficial insects proportionately, so the balance between them is unchanged. From time to time parasites and predators have been bred and even imported to deal with particular pests, but costs are too high and distances too great for this method to be used in forestry save in exceptional cases, and to-day it is generally accepted that birds are the best agents to use.

We have to take into account that insects go through four different stages, in all or any of which they may be vulnerable. Some birds hunt for and eat the eggs, in cracks in the bark or on twigs, leaves and buds. Others eat the larvae, some only when they are free-living, some by making holes and catching them under the bark or even in the tree itself. Others eat the pupae, especially those which pupate amongst dead leaves on the ground, while others again eat the perfect insect. Many birds are useful at more than one stage, while many insects are more vulnerable at one stage than at the others. Therefore to maintain a balance, we want numbers of different species of birds rather than high numbers of any one species, so that we can catch each of the very numerous insect species which damage our woods at its weakest point.

It is sometimes said that to encourage birds and to give them nest-boxes, etc., is to disturb the balance of nature. This is not correct: it is to restore it, as we have already disturbed it by removing old and holey trees and replacing them by young plantations. The natural wood is a selection wood, in which trees only die from natural causes, and this means that there are numbers of over-mature trees in which there are holes for breeding; in passing, these holes are also used by bats, which destroy large numbers of insects. Woodpeckers rarely if ever use sound trees for their nesting holes, while Tits, etc., require ready-made holes, or rotten branches, etc. A natural wood will also contain gaps from various causes, where shrubs and undergrowth spring up. Browsing animals, falling branches, etc., break the tops and produce the thick little whorls of shoots which form such desirable nesting sites; even insects help in their own control, as the few nests found in a Scots pine plantation are very often sited at a point where the leader has been lost, and there is a bend in the stem, with thicker and more numerous side branches. In fact, although birds destroy far more insects during the breeding season than at any other time, good forestry tends to remove all the best nesting sites, and so to drive the birds elsewhere just

at this very important period. In winter many birds use holes for shelter, and so in a well run wood have nothing to help them to keep warm. We also tend to cut out the many berry-bearing species on which they depend for food in hard weather.

A point worth noting is that the size of clutches of eggs depend to some extent at any rate on the food supply. Thus in a Lemming year, owls, hawks, etc., have more eggs than usual. I have myself a rather uncertain recollection of finding a number of big clutches of eggs in an area where Teak defoliators were denuding the plantations of leaves, and there were certainly big clutches in an area in which bamboo was flowering. I did not take special notes at the time, so can only give an impression instead of figures, but it is what one would expect. It would mean that if any natural cause such as frost took a very heavy toll of birds, while leaving their prey relatively numerous, the consequent abundance of food for the survivors would lead to big clutches, and so to the quicker restoration of the balance, as long as the nesting sites were available.

Even after we have got stomach analyses, it is difficult to express the results. Is one Chalcid, about the size of a mudge, equal to one cockchafer? One is inevitably reminded of the manufacturer of potted meats, who claimed that in his shrimp paste, horse and shrimp were 50/50—one horse and one shrimp. There are variations in detail in the way this numerical method is used by different workers, such as the total numbers of insects, seeds, etc., found, and the number of times each food is found in a given number of analyses. Collinge (2) uses the Volumetric method, estimating the violume of each kind of food in each specimen or group of specimens, and its percentage of the whole, but it is difficult to assess the relative value of various pests which all do damage in their own way. Is 1 *Tortrix viridana*, a defoliator, equal to 1 *Tortrix* (*Evetria*) *buoliana*, which turns the infested pine into little but firewood with a "Post-horn" bend? Is a full-grown Leopard Moth larva the equivalent of the same volume of *Hylobius abietis* or *Myelophilus piniperda?* Or of Ichneumons, Chalcids, etc.? I must confess I do not know the answer, nor have I anything better to suggest. The personal opinion of the investigator remains just a personal opinion, without figures of some kind, comparable with other figures, to back it up.

It seems almost as if the longest way round might prove the shortest way home, and that detailed data of sample plots in which birds are encouraged, set against control plots and compared after 5 or 10 years might be the best way in which to reach anything like finality. An ornithological friend wrote that it should be simple if tedious to measure up the growth in a plot with plenty of nest boxes. and compare it with a control plot with none. This actually only covers one source of loss due to insects, actual loss of volume. That there is some loss of volume seems clear when one sees the holes in the leaves of an oak in the autumn. The leaf surface is just not there to assimilate food. In pines, a shoot attacked by *Lophyrus pini*, the Pine Sawfly, is always undersized with small needles and reduced growth the next year. In teak plantations which had been totally defoliated by *Pyrausta machoeralis* and *Hybloea puera*, I have found that both the annual ring for the year of the attack, and that of the next 1 or 2 years are smaller than both the rings before the attack, and the rings 3 or 4 years later, when the tree has recovered. If we could cut out this source of loss enough to let us reduce the rotation even by a year or two and still produce the same volume of timber, the saving would be very considerable. Also if, by use of nest boxes in surrounding woods to supplement traps, we could replant pine areas at once without danger from insect attack, and so save the 4 or 5 years which these areas often lie fallow, we should effect a financial saving.

But there is another aspect of insect control which is difficult to estimate, that is its insurance value against plagues of insects, with deaths which may follow amongst the growing stock, upsetting the working plan, and causing money loss through the enforced felling and sale of immature timber, etc., not only disturbing local markets and prices and felling timber before it is mature, but having to hold other woods till they are over-mature to even out work and the income.

We have been little troubled by plagues of this sort in the past, but we are now using methods which approach the continental type, and must expect continental troubles to come with them.

There is a sequence of birds which live in plantations, from their formation onwards. In the first year or two the birds are those of open spaces or weedy patches. Col. G. R. Maitland of Burnside tells me he has had pipits in an open birch wood, under-planted closely with Hemlock and Norway spruce, from the start up to about the 10th year, when they began to disappear. St. Clair Thompson (6) says that Whinchats and Stonechants do much good in the early years, although I have myself found that they disappear very early. Birds such as the Willow Warbler, Yellow Bunting, Garden Warbler, Redpoll, Whitethroat nest both in the small trees and in the weeds on the ground until canopy is formed, say about the 8th to 10th year. After that the hedge-row and thicket birds come in, Chaffinch, Greenfinch, Thrush, Blackbird, Hedge Sparrow, Wren. These are the main type until the trees are big enough to contain holes, or to carry nest boxes, which is not until the 20th to 40th year, when Tits, Woodpeckers, Nuthatches, etc., start to nest.

Such birds as the Willow Warblers, and to a lesser extent Yellow Buntings, which nest near or on the ground, in tufts of grass, the lower branches of small trees, etc., are found throughout the life of a wood in suitable places, such as the edges of rides and firelines, if the herbage is suitable. They require thick, rough growth of almost any sort, brambles, bracken, etc., preferably broken up, and not in continuous masses. In an 8-year-old Larch plantation, rather open in parts, with heather and grass on the ground, 10 Willow Warblers were counted, more or less, in 5 acres. This is singing birds, *i.e.*, males, and the exact figure cannot be guaranteed, as they move just at the wrong moment. But there were something in the region of 2 pairs per acre, with 2 cock Chaffinches and a Yellow Bunting in the same 5 acres. Both Willow Warblers and Yellow Buntings nest along the edges of the windbreak referred to below, but they have not been counted.

Taylor (5) reports that in the Forest of Dean there is no difficulty in getting nest-boxes occupied, up to about 2 boxes per acre, which is generally accepted as the most desirable density for control, in 2 plots of 35 and 37 acres in 130/140 year-old oak wood with sporadic undergrowth and in one plot a few large beech. It remains to be seen whether we can do the same in coniferous woods of corresponding age, as has been done on the Continent.

Taylor (5) also records that in one of the Forest of Dean plots 34 out of 74 nest-boxes were tenanted in the first year, 54 out of 82 in the second, and 71 out of 82 in the third; in the other plot 50 out of 70 were tenanted in the first year and 62 out of 70 in the second. This progressive increase in the number of boxes occupied in a given area in the first two or three years has been noted elsewhere. It suggests two things: first, that while the ultimate limiting factor to the bird population in any area must always be the food supply, for hole-breeders at any rate, it rarely comes into action, as the *actual* limiting factor in woods, which operates first, is the availability of nesting sites. Apart from numbers, not every hole in a wood is suitable for nesting—the size may be wrong or it may face in the wrong direction—and the provision of well-made nest-boxes, put up so as to face the right direction, leads to an immediate increase in suitable sites and so to nesting birds. Secondly, the increase in boxes occupied after the first year may be because birds get used to them through time. But it may also be that a nest-box, however well made, is not just the same as a natural hole in the tree, so it will be only the most enterprising individuals which use them at first. In subsequent years birds which were themselves hatched in nest-boxes and are accustomed to them will naturally try to use them in their turn. This can be shown by ringing nestlings in a plot the first year in which boxes are put up, and seeing if they return to nest themselves.

The above is one interpretation of the fact that the numbers of nest-boxes tenanted increase progressively over the first two or three years. But it is a possibility that the birds using nest-boxes were using natural holes in the area before the boxes were put up. It is not considered likely, especially in view of Taylor's (5) Pied Flycatchers, which were not known as breeders in the area before they tenanted nest-boxes. The matter could be settled by making a census of birds one spring, putting nest-boxes up in the winter, and making another census about the same date the next spring. In any case, there is no automatic increase in the total number of birds in a big area merely because nest-boxes are put up, and in the first year birds must come in from

outside. In a big area the increase will be gradual, but will be helped because nest-boxes combine all the best features of natural holes, and so the survival rate of nestlings is probably high; and because some birds at least do not breed in any given year, one cause of which is thought to be failure to find and keep a good nesting site, a cause which is removed if there are plenty of boxes.

In younger plantations, up to 30 or perhaps 40 years old, before nest-boxes can be put up there seems to be distinct preference for the Spruces, especially Sitka. I have some figures, but am not yet satisfied with them. Of the tree species examined, from about the age of 6 years up to 20 and probably to 40, for those birds nesting in trees (not on the ground) Sitka spruce is very good, Norway spruce good, Thuya, Cypress and Douglas fair; Scots pine and Larch bad. Very few broad-leaved plantations have been seen, but while young they seem to be about the same as Scots pine and Larch, that is bad.

Anything like definite figures are very difficult to get, and, when one has them, there always seem to be modifying factors—Cottages, which have in their garden attractive feeding sites, or alternatively which with their cats and children tend to keep birds away; open policy woods, which are always attrective; rubbish tips, which are attractive; and rights of way and picnic sites, which are not. There is a wind-break at Tullach Ard, 15 years old, and consisting of small blocks of various species, all the same age and all more or less normally grown. It has been so treated that it is reasonably certain that only nests of the last 4 years have been counted. It is an Island site, that is a nesting site in the middle of fairly extensive feeding grounds, and in such sites the density of nests is always high. The numbers of nests found, old and new, in each species, per 100 trees are:—Sitka spruce, 15; Norway spruce, about 8; Larch, 1; Scots pine, 0.3; Willow, Alder and a small patch of mixed Oak and Larch, 0. Thuya, Cypress and Douglas were interpolated from a count in another area, not exactly comparable, as being about 2 to 4, *i.e.*, between Norway spruce and Larch; Hemlock, again from another area, 0.

These figures, although they are high, agree fairly well with counts of nests in other woods near Perth, that is the numbers in the different species although lower, remain in much the same proportion; perhaps it would be better to say that the order of popularity remains much the same. It is not only for whole plantations that this holds good; 2,000 Scots pine in one plantation about 20 years old contained 1 nest. A Norway spruce in the middle of it contained 6, while about 150 Sitka spruce 12 years old at one end contained 19. The species counted were Blackbirds, Thrushes, Chaffinch, Hedge-sparrow, Greenfinch, with probably odd nests of Redpoll, Bullfinch, Yellow Bunting, Garden Warbler, Longtailed Tit and possibly other species also.

As far as I can make out, most birds will feed in any wood, but some at any rate are much more particular as to which species they nest in. I have not yet collected sufficient data to make out a complete case, but have given the above summary of results up to date for what it is worth. There seem to be good reasons for the preferences shown: Scots pine and Larch, cover too light; Thuya, Cypress and Hemlock, branches alternate and opposite, and so no suitable nest-platform. Broad-leaved species are not in leaf when the first nests are made, so there is no cover, also there is no suitable nest-platform. Norway spruce has too many fussy little twigs, so access is difficult. It is hoped to publish a fuller note on this preference for certain species when more data are available, and the above is, as it were, a progress report only.

The application of this information to forestry would be to plant up any suitable patches of ground in plantations with spruce, preferably Sitka, which would serve as Island sites for nesting from which birds would feed in the surrounding plantation of species unsuitable for nests. Although they seem to dislike, say, Scots pine and Larch for nesting, they will feed freely in them. Suitable patches for spruce would be the wetter spots, and to plant them with this species would in fact be good forestry, making full use of the factors of the locality. Further research is wanted, but as an estimate and nothing else, a plot of a quarter of an acre should supply nesting sites for birds to police 30 acres round it.

I cannot trace the reference, but I think a census of birds in different types of country have been taken, with the result that "Mixed Broad-leaved" woods were said to contain most bird life, with Agricultural land and coniferous woods a long way behind them, and Moorland a very

poor last. All broadleaved woods are not necessarily well stocked with birds. Taylor (5) says: "The native avifauna of the Forest of Dean is peculiarly disappointing, both as to species, numbers and distribution, in spite of so much of the area being under hardwood crops, chiefly oak. Broadleaved and mixed woods usually provide optimum conditions for bird life......" I have found the same elsewhere, that is that broadleaved woods do not necessarily mean a high number of birds, although I have not examined nearly as many woods as I should like. Birds are usually numerous in the "Policy" type of wood, where trees are mostly over-mature and open, with a considerable amount of bracken, brambles and other miscellaneous undergrowth and weeds on the ground. There is often ivy on the trees as well. These conditions are not those found in a well run wood, and I suggest that the numerous birds found in "Mixed Broadleaved woods" are not nesting in the trees proper at all, but in the holes in them, the ivy round them and the weeds under them. If this is correct, properly run broadleaved woods want just as much help from the forester to maintain their bird population as conifers do.

Besides nest-boxes, and the provision of suitable species such as Sitka spruce at intervals, a good many other methods of encouraging birds will be found in Martin Hiesemann's book, "How to Attract and Protect Wild Birds" (3), but one must not mix up the preparation of a bird sanctuary, where the only object is birds, with the definitely commercial business of ensuring a sufficient supply of birds to keep pests in check. There are useful methods of pruning shrubs so as to form cups for nests, and using odd corners for small patches of shrubs for nesting purposes, and for berries for winter feed. Various types of water supply and feeding houses against winter scarcity are also given. It is definitely not desirable to hand-feed birds entirely through the winter, but the problem is to teach them where food can be obtained, before it becomes a vital necessity. It can be done by finding a food which they will only eat in quantity when in dire straits, or by strictly limiting the quantities put out at normal times, increasing them only in really hard weather. In spite of the trouble, there are points about winter feeding near the nesting sites, that is within a mile or so of them. It keeps the birds in the woods where they are wanted in the spring; while they are in the woods they will eat any insects they find, and so further reduce their numbers; and, as many birds die of starvation in really hard weather, it keeps them alive, so that they are still there to nest in the spring. More investigation, with detailed costs, is wanted before we know how much help it is economically justifiable to give.

Bearing in mind the various nesting sites used, it becomes of importance just when certain forest operations are carried out. Some birds start nesting in March, many are nesting in April and the rest in May, while second broods will be coming along up to at least the end of July. So from the beginning of April at any rate until the end of July, operations which disturb nesting sites should be kept to a minimum. Weeding must be done when wanted as it is no use saving trees from insects if you kill them with weeds. But cutting coppice shoots, etc., should not be done in summer if avoidable: it is thought that 6-to 8-year old plantations, in which the trees are packed tight in coppice shoots are not good nesting sites. Access is difficult. They are much better when the trees are clear. In older plantations brushing up to 7 feet at any rate does not seem to affect nesting. In fact, small birds fly up and down between the stems. But if there are plots of spruce as nesting sites in plantations of other species, these should be brushed up in winter.

There are several good types of nesting-boxes. Taylor (5) gives details of one he has found useful. Hiesemann (3) gives the Berlepsch box, which is a copy of a woodpecker's hole. Most hole breeders will use a square box like Taylor's but I have only known woodpeckers use the Brelepsch type freely. I must add that my experience is not very great.

There is also a type of nest-box, in the form of a complete box with the top half of one side removed which I have seen considerably used both in Germany and in Bird Sanctuaries in Great Britain. It is tenanted by Robins, Spotted Flycatchers, and Redstarts. One sometimes sees them on the verandahs of houses, and in this situation they are often used, especially if the birds nested on the rafters, etc., before they were put up.

Bats do not come into Ornithology, but their habits are very similar to those of birds in many respects. They are insectivorous, they have big appetites and they live in holes in trees; like tits, etc., when all holes are removed from a wood, they can no longer live there.

Very little definite seems to be on record as to the details of their feeding habits, but Brooks (1), P. 20, records finding the remains of *Evetria buoliana*, the Pine Shoot Moth, in the stomachs of long-eared and short-eared bats. Millais (4) gives *Triphaena pronuba*, *T. fimbria*, *Agrotis saucia*, "Tineid Moth," "Dors and Chafers," *Plusia gamma*, *Taeniocampa* spp, *Rhizotrogus solstitialis*, Poplar Hawk moth, noctuids, and *Tipula oleracea* amongst others as being eaten. I know myself that they catch and eat Cockchafers. Hiesemann (3) notes that if bats are found in nest-boxes they should not be disturbed, as they are as useful as the birds. I cannot find that anyone has worked on bats as controls for insect pests in plantations, but their food and their big appetites give promise that they might be one of a number of controls all working together.

Forest Ornithology has been very much neglected in this country up to date. An effort has been made above to call attention to some points, in many cases derived from continental sources and so not certainly correct for this island. It is a sketch and no more, and there are many deficiencies. It is usually held by foresters who think about it at all that insect pests do much damage, and that, if they can be harnessed to our service in any way, birds are the cheapest and most natural control agency. A scientific, and so unbiased, investigation seems to be urgently needed. An effort is being made to get some of the preliminary work done, so that when things become normal again, work can be started without delay. I will be very grateful for any information sent to me at Tullach Ard, Balbeggie, Perth, and keep a record of it. Points on which the man on the spot will know more than anyone else are, for example, bird species eating insects where those insects have become so numerous as to be a plague, and any plots where nests seem to be specially numerous, with the reasons if known. But there are innumerable other matters in which the man whose every day work keeps him in the woods gets the best chance for observing, and research is little but a long series of careful observations.

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SUMMARY (FREE OF COPYRIGHT).

Forest Ornithology is the very detailed study of our common woodland birds.

Nestlings are fed on a diet which is mainly or entirely insects. Mortality is heavy in the first 3 months, so birds eating this beneficial diet preponderate.

Provision of nest-boxes is to restore the balance of nature, upset by the removal of old and holey trees.

The sequence of birds in plantations is discussed.

Certain tree species are preferred to others for nesting by birds which nest off the ground. This can be applied to woods by planting up patches with desirable species.

Bats are suggested as a parallel control with birds.

FORESTER AND CHEMIST—PARTNERS

BY M. H. BRUNER.

(Consultant, Extension Division, E. I. du Pont de Nemours and Company, Inc., Clemson, S. C.)

This article by a forester and Senior Member of the society of American Foresters emphasizes the importance of wood as one of the basic raw materials of industrial chemistry. Through the development of new and improved products, numerous examples of which are cited, the chemist is enabling the forests to contribute more fully to our well-being and is at the same time providing increased incentive for their better management. An expanded and dynamic programme of research is needed to insure still further progress in this field, which offers one of the most promising means of strengthening the hands of the forester by creating a profitable outlet for the products, and more particularly the by-roducts, of his efforts.

Now more than ever, the forester and the chemist are partners. With the war, wood has become a critical material, and the almost insatiable needs of global conflict have bitten deeply into our forest lands. Foresters must lead us in the rehabilitation of our reserves.

In war or peace, wood is one of the basic raw materials of industrial chemistry. It is an important source of the cellulose required for the making of hundreds of things from explosives to textiles. The chemist views it also as a versatile material in its own right, a worthy subject for constant research so that it may be improved to do its age-old jobs better and to take on new ones.

This attitude is vindicated by recent events. With the aid of chemistry, wood has made possible two outstanding war weapons—the Mosquito, which is the world's fastest bomber, and the PT boat, scourge of the enemy everywhere. Without the laboratories in which the special adhesives for plywood were formulated, neither of these would have been possible.

The Forest Products Laboratory, federal and state experiment stations, and industrial chemists have been seeking constantly for more than a half century to improve wood. Their efforts have been given much impetus by the present war.

Even while developing materials that have come to compete with wood in some fields, research organizations like that of du Pont have been constantly at work on the problem of its improvement. Abundance is one of its great advantages, but wood has certain disadvantages which the chemist can help to minimize. For one thing, wood is not a uniform material and may vary widely in quality even in the same species. Also, wood is susceptible to atmospheric conditions, fire, fungi, and many other factors. The chemist seeks ways to give wood greater permanence, utility, and resistance to its natural enemies. Chemical research in wood is nearly a century old by now but only in recent years have the strides been long. To-day, as an example of what has been accomplished, the armed forces are depending constantly upon no less than 800 different wood products.

It has been a hundred years since Alfred du Pont took some cotton and treated it with nitric and sulphuric acids after a formula worked out in Europe. The result was one of the first samples of guncotton to be produced in America. Until recently, cotton was used almost exclusively for this purpose. Nowadays much of the cellulose for explosives comes from wood instead.

Then in 1869 John Wesley Hyatt, an American, mixed camphor with nitrocellulose to produce an ivory-like substance which he called celluloid, and which was the forerunner of the modern plastics industry. Nitrocellulose plastics are now widely used for such common articles as fountain pens and pencils, handles for brushes, piano keys, optical rims, wood-heel covers and a multitude of other articles.

A limiting factor in nitrocellulose plastics is that they burn readily. However, in the 1920's the slow-burning "Plastacele" cellulose acetate plastic was developed. It is a cousin to "Pyralin" cellulose nitrate plastic. ' Plastacele" is used for such articles as combs, costume jewelry, door knobs, protective goggles, automobile accessories, and telephone receivers.

While these improvements were being made in cellulose plastics, du Pont chemists and others were finding different methods for utilizing cellulose. One of these involved the coating of textiles with nitrocellulose to make a material which in some respects resembles leather. Another important development was "Duco" pyroxylin lacquer with cellulose as a basic material.

"Duco" is the finish that broke the last bottleneck in mass production of automobiles by reducing drying schedules from days to hours.

The cellulose used in making plastics, and also that employed in the manufacture of nitrocellulose for coated fabrics and pyroxylin lacquers, may be derived from either wood pulp or cotton linters.

Another important cellulose-based product is cellophane, which went into production in this country in the early twenties. Cellophane is made from wood pulp. In 1924 it sold for $2.64 a pound. To-day the cost per pound of a far better cellophane is 33 cents. This is an outstanding example of the ability of industrial chemical research to improve products and reduce cost at the same time.

Still another cellulose product highly important in the national economy is rayon, a textile fibre produced from wood pulp or cotton linters, or both, by several methods. Although the idea of an artificial fibre was conceived in the 17th century and rayon was produced commercially in Europe prior to 1900, the first factory in America was not operated until 1911. Since then the research chemist has steadily improved the quality of rayon and reduced its cost. From 363,000 pounds in 1911, the production of rayon in this country rose to more than 723,000,000 pounds in 1944.

World War II has made us more conscious of the importance of wood, and chemistry is responsible to a great degree for this change in attitude. As a matter of fact, chemical science now appears mobilized in the defence of wood, seeking more and more means to protect it from the destructive forces of decay, termites, fire, and the other natural enemies that wood encounters all the way from the growing tree to the finished product.

It is now possible to enhance the appearance, usefulness, and basic value of wood by chemical treatment. Chemistry is coming to the aid of wood by adapting it as a material with specific properties for specific purposes.

The value of chromated zinc chloride as a wood preservative and termite protectant—making wood last from three to ten times longer—is now generally recognized. However, the importance of this compound for rendering wood resistant to fire is not so generally known. It is a fact that ordinary pine, impregnated with two to three pounds of "CZC" per cubic foot, takes on exceptional flame-resisting characteristics. The chemist here is getting around one of the chief limiting factors of wood—its flammability.

Foresters and landowners are searching continually for uses for trees removed in thinning and improving forests. One of our big forestry problems is getting rid of undesirable hardwoods. The fibre-board industry, of which the Masonite and Flinkote Corporations are examples, has found one answer to this problem. Many companies are now using these inferior trees in the production of such things as sheeting and insulation board. The wood is ground up, converted to fibres, and then reassembled and pressed into fibre board to meet almost any desired specifications.

The war brought plywoods into their own. On the Mosquito bomber and PT assault boat, plywoods, which resist weathering are used. These plywoods, the laminates of which are bound together by recently developed adhesives, can be boiled in water for several hours without serious consequences. They resist shrinking and swelling due to moisture. They can be used for paneling, flooring, doors, and furniture.

Approximately 30 per cent. of wood is lignin, the substance that cements the cellulose fibres together. Until recently few chemical uses for lignin were known. Now research is directed towards using lignin in wood plastics.

The chemist can materially alter most of the natural properties of wood. A piece of red gum, coming green right off the saw, if soaked in a saturated solution of urea, dried, and then heated to 200° F., can be tied into a knot and set there. At that temperature the treated wood becomes plastic.

A new process for improving wood involves the use of "Arboneeld" dimethylolurea and urea to produce an insoluble resin in the pores and fibres of the wood. The outstanding result of this treatment is a marked increase in hardness. With suitable selection of treating conditions and resin content, there is also a reduction of approximately 40 per cent in the extent to which the treated wood will swell from the oven-dried to the water-wet state, as compared to untreated wood of the same species. The treated wood is also improved in resistance to attack by fungi, pests, rot, chemicals, and flame.

These are just a few examples of chemistry's more recent contributions in making wood better

thus expanding its usefulness. These developments did not happen overnight or haphazardly. They are the fruit of patient work over the years in laboratory, pilot plant, and factory. Promising as they are, we cannot afford to be satisfied with them. We still must learn how to make the best use of them in our forest industries, and we must not relax in the quest for still more improvements.

If the rich and diversified forest resources of our nation are to contribute more fully to our well-being, we need an expanded and dynamic research programme, which, for one thing, should be aimed at utilizing more and more by-products of forestry. If carried out with patience and determination, research will pay real dividends in the proper utilization of this basic natural resource.

—*Journal of Forestry*, Vol. 43, No. 6, June, 1945.

THE LAMENT OF A SOIL PARTICLE

By J. W. Cleghorne.

We soil particles, like humans, must pay rent, and, in the event of failure to meet our liabilities, ejection occurs, followed by death from exposure. As tenants, we have a pleasant existence. How safe and sheltered we are domiciled where we belong. We and our hosts—the sand grains around which we are clustered—have complete understanding, our only desire being to assist Nature by the addition of our quota to that wonderful power which not only creates, but also regulates the material world.

To achieve this object, our homes have been founded in and on the soil surface; the walls and roof-coverings of these homes are constructed of grass, while humus in the form of decaying grass provides the floor-coverings. We occupy these strange dwellings as very peculiar tenants. For instance, the roofs and walls of our homes demand continuous attention and repair to enable them to leak as uniformly and as gradually as possible, while we, to be thoroughly efficient, must reside under the floor-covering—the carpet of humus. To create such living conditions unaided is impossible. Fortunately, success in this direction can be achieved by co-operation, *i.e.*, we co-operate with the water and grass, and Nature blesses this soil-water-grass trinity.

Soil-particles

We soil particle tenants pay rent for this housing, however, in the form of conserved water for the provision of the necessary sustenance for the maintenance of the walls, roofs and floors of our houses by promoting the vigorous growth of the grass, our landlord. The grass, in return, like a good landlord, provides ideal housing conditions: it keeps our domiciles in such a perfect state of repair that the force of the raindrops is dissipated, by the interposition of the grass, to such an extent that the water falls gently on the humus carpet under which we reside. The beneficence of our landlord does not end there: he is continually replenishing the humus carpet to reduce still further the power of the raindrops, so that the rainwater reaches us slowly and gently as if it were soaking through blotting paper. Time is thus allowed to enable us to store it in multitude of minute natural underground dams.

As a result of this good treatment we feel that an increased rental is just, and we gladly pay by conserving rainwater where it falls, so that it is constantly available for use by the grass as required. This perfect co-operation completes the cycle, and as a result the members of this co-operative trinity are in complete harmony with Nature, and are enabled to maintain man and beast in health, happiness and contentment.

Man's mismanagement

Man, with his incorrect farming methods, makes it impossible for the cycle to repeat itself in the same order and with the necessary intensity. The result is that the power of the cycle is constantly being reduced with such ever increasing rapidity that its destruction is inevitable.

And how does man interfere with this vital cycle? The majority of farmers, quite unintentionally, due to lack of knowledge, and for other reasons, conduct their grazing operations in such a manner that initially our landlord, the grass, deteriorates slowly, and finally at an astonishing rate until complete denudation results, and we soil particles are left exposed and totally unprotected.

How does this faulty grazing management affect us—the soil particle tenants? When the grass commences to fail in health it becomes impossible for our houses to be kept in repair. Leakage through the grass walls and roofs becomes excessive and we are unable to conserve all the rainwater where it falls, with the result that our landlord receives less rent in the form of water for his sustenance, and his condition steadily becomes critical. The climax now approaches rapidly. Our only remaining protection is the humus carpet, but this is also steadily washed away by the water which we no longer have enough time to conserve, and our exposure is such that the death of the grass is inevitable. The final act of the tragedy is now staged: with the landlord dead and our humus carpet gone, our exposure to the full force of the rain is complete, and ejection or death soon stares us in the face.

Our capacity for storing water in the interstices between the multitudes of soil particles still exists, but the rush of the water over the soil surface during rain is now so swift, due to the death of the grass and the absence of the humus carpet, that insufficient time is provided to permit our underground reservoirs to fill.

Eventually our last efforts are nullified, and any supply to these vast reservoirs is prevented by the further destructive action of the rain. The raindrops now bombard us with such force that our ideal partnership of soil and sand is dissolved, and many of us are ejected from our homes, because, with our disintegration, mud and sand result. The mud is washed into the voids between us and seals them so efficiently that water conservation in and under them is impossible. The rainwater now runs off the soil surface totally uncontrolled, causing our death during its journey and leaving destruction and desolation in its wake. Through no fault of their own, but owing to recklessness of *man*, the upper soil particles are ejected from their homes because of their inability to pay the rent, while the lower soil particles lie dead and buried under a shroud of mud.

Grass—our landlord

Grass, our landlord, is the basic sustenance of man and beast, so that, if this and succeeding generations are to survive, we, the soil particles, must pay him his rent regularly and in full—not in currency, but in rainwater conserved where it falls.

—*Farming in South Africa*, December, 1944.

TREE SPREAD FOR AUSTRALIA

Australian foresters are returning today to a vast and picturesque undertaking—the creation of a spread of trees, designed to serve the nation's needs, throughout their vast but largely arid continent.

In surveying and marking the countryside with their 6×6 and 8×8 planting designs, they will be assisted by new ideas and techniques adapted from wartime constructional projects. The continental umbrella of trees will not be finished in a day, or a year, or perhaps in a century, but it will go forward steadily all the time, providing new timber resources holding down the soil, conserving precious water supplies, making the inland more habitable.

When Nature allocated the world's 7½ billion acres of forests, she was especially niggardly to Australia. Finland, Sweden, Japan and Nigeria have more than half their total area covered by forest. Canada and United States, each comparable in size to Australia, have one-third and one-fourth forest land respectively. Russia has 3,667,500 square miles of forest, almost half the country's area. Of 28 countries with worthwhile timber supplies, Australia comes last in ratio of forest to total area.

The climatic effect in the dry inland is often disastrous. In the hottest localities, the thermometer hovers between 100 and 120 degrees in summer. Rivers, creeks and dams evaporate at the rate of 90 inches annually, which is faster than the inland yearly rainfall. Good soil, which should be protected and held down by tree roots, is lifted by hurricane winds and carried a thousand miles out to sea.

The answer to these problems is to plant trees—and more trees. Australian pioneers first appreciated this fact seventy years ago, when *Pinus radiata*, a native of California, was planted in South Australia. But hampered by lack of motor transport, aeroplanes and modern earth equipment, pioneer foresters

made slow progress. World depressions and world wars also upset tree-planting schedules.

Short of Softwoods

Forests are needed not only to provide a timber supply, but also to maintain an adequate water supply. Scientists say wooded land will store about 46 times as much moisture from rain and snow as unforested land of similar composition.

The economic link with population has also been worked out. If Australia's forests provided a maximum of both hard and soft woods, the timber supply would be sufficient for a population of 22,500,000 people—almost three times the present number.

Actually, however, hardwoods predominate, and millions of feet of softwoods are imported each year. As the forestry plan proceeds, it is hoped to achieve a better balance of hard and soft woods. The hardwoods are world renowned for their usefulness and longevity in constructional work. As an example, pier timbers of ironbark, jarrah and redgum, built into a Port Melbourne wharf eighty years ago, were recently extracted during rebuilding operations, and were found to be in excellent condition. They had resisted marine organisms, and were used again for ship-building berths, slipways and similar work.

Much of the original Australian forest was destroyed in the process of settlement, or by forest fires. Cedar and red gum plantations vanished under the impact of the axe. In one State alone, a forest area of 30,000,000 acres was reduced by two-thirds in a century. Tightening of laws in recent years has ended this reckless squandering of national assets.

Of the seven main forest areas in Australia, six are on the eastern side, stretching from Queensland to Tasmania, and the other is in the extreme south-west corner of the continent. The total area of about 30,000 square miles looks insignificant alongside the half million square miles of United States forest, although Australia and the U.S. are about the same in area.

An Australian forestry conference 25 years ago resolved that a forest area of 24,500,000 acres was necessary to provide for the future requirements of Australia, but expert foresters consider this was an optimistic figure. They say 19,500,000 acres represents the possible limit for permanent reservation in Australia.

If future population and economic conditions require a larger area, presumably it will have to be planted.

Growing Demands

Division of forestry control between States and Commonwealth makes it more difficult to deal with on a truly national basis, although Forestry Congresses have paved the way for co-ordinated action in some directions.

The broad functions of Australian forestry authorities are: the securing of an adequate reservation of forest lands; introduction of proper measures for scientific control and management; protection of forests; conversion, marketing and economic utilisation of forest produce; establishment and maintenance of coniferous forests and remedy of the existing deficiency in softwoods.

All timbered lands are being surveyed with a view to eliminating those unsuitable for forestry. Dedications of new areas as national forests have added to the permanent forest estate.

Timber used for war purposes amounted to 267,000,000 super feet in the two years before Japan entered the war, and rose to 1,437 million super ft. in the subsequent 3½ years. Without imports of Canadian lumber it would have been impossible to case wartime goods.

Growth of industry has created manifold uses for Australian timber. It is needed for joinery works, box and case factories, for sleepers or rail ties, piles, poles, fencing meterial, veneers and plywoods, mining and fuel. Under wartime control, it was a raw material for munitions and for defence construction.

Manufacture of paper from Australian-grown timber has been esablished in three States. In island Tasmania, two large mills are making paper from indigenous hardwoods.

During the war, the peeling of logs for production of match-board and sticks was carried out in Victoria and South Australia. Other products from Australian trees are charcoal, eucalyptus oil (bulk of which is shipped to U.K. and U.S.), sandalwood and sandalwood oils for medicines and perfumes, yacca gum for varnishes and lacquers, tan barks from the golden, black or green wattles and certain types of eucalyptus.

Forest Distribution

Nine out of ten Australian trees are hardwoods belonging to the genus *Eucalyptus* (Gum trees). Only small areas of virgin forests still remain. Including the mallees, over 400 species of eucalyptus are now recognised, but the chief commercial varieties are confined to about 50 species. In addition to the hardwood forests and cypress pine belt, the coastal strip of Queensland and northern New South Wales provides "rain" or "brush" forests. These tropical forests furnish serviceable hoop pine and furniture timbers such as black bean, Queensland walnut and maple and silkwood.

The heaviest forests are in Victoria and Tasmania. Western Australia is noted for its kauri. Most valuable timber areas are in New South Wales, with Western Australia, Victoria, Tasmania and South Australia following in that order.

In New South Wales, the total forest area, although not large, contains a great variety of useful timbers, including such renowned constructional wood as ironbark, tallow-woods, spotted gum, blackbutt, red mahogany and turpentine in the hardwoods, and cedar, beech, brushbox, hoop pine, coachwood, native cypress pine and teak in other woods.

In the half million square miles of undeveloped northern territory, there is a little bit of cypress pine, paper bark and some useful eucalyptus, but not a great quantity of useful timber.

In general, Australian legislation provides for control and management of State forests and timber reserves, the licensing of timber-getters and sawmills, organisation of a system of education in scientific forestry and research. Provision is made also for the permanent dedication of reserves for the preservation of natural flora, for the protection of water supply catchment areas, and for the prevention of erosion.

In the Australian economy, forestry represents a Rs. 12,84,00,000 industry—equal in value to coal output. Forestry involves a multiplicity of vocations, from road construction to operating radio transmitters, and includes axemen, nurserymen, planters, tractor operators, assessors, engineers, cooks and survey assistants.

Big Plans

Postwar programmes provide for large expenditure on Australian forests. It seems likely that in the next five years the various authorities will spend between Rs. 16,00,00,000 and Rs. 21,50,00,000 on the next stage of creating Australia's man-made forests.

More sawmills, large peeling and plywood plants and considerable extensions to the pulping and paper making industry are planned. It is confidently anticipated that numerous industries will be attracted by the availability of ample supplies of this fine general utility timber.

In some areas, training camps are proposed to cope with several thousand men. These camps, each accommodating 50 or 100, will train returned soldiers for forestry employment. Elsewhere workers will be concentrated in forest townships, to avoid exposing small groups of forest workers and their families to the dangers of fire. These townships will also provide educational, recreational and other amenities.

Aeroplanes are being used in some sections to complete forest surveys and to assist fire patrols. Five protection plans include elaborate spotting and communications systems, use of modern fire fighting equipment, employment of big gangs of fire fighters at threatened points, and the minimising of fire hazards. Army roadmaking equipment will be used to build roads and forest tracks, which will provide a strategic means of fighting fires and also offer facilities for extraction of timber and for normal transport.

Thus the Australian forestry plan begins with plotting out the land for the young plants, and extends through all phases to fate of the fully grown, matured tree and the need for replacing the tree when it is used.

—*Australian Agricultural Newsletter* (Release No. AGN/122 of February 1946).

VOLUME 72 NUMBER 8

INDIAN FORESTER

AUGUST, 1946

CONTOUR TERRACING OF FIELDS IN GUJRAT DISTRICT.*

BY M. KHEM CHAND MALHOTRA, P.F.S.

Scope of Work.—In Gujrat district there are about 1¼ lacs of acres of undulating or sloping and partially terraced cultivable *barani* (rain-fed) lands which require to be reconditioned into terraced or *watbandi* fields. These lands lie within an 8-mile wide strip along the Jammu border between the Chenab and Jhelum rivers in Gujrat and Kharian tehsils and on both sides of the Pabbi hill range. Rainfall varies from 16 to 30 inches.

Definitions and Terminology.—The term *watbandi* is used loosely to denote either or both levelling and embankment on all gradients. This necessitates a more exact terminology as below :—

i. "Terracing with *watting* (contour ridges)": levelling of a field on slopes steeper than 1 in 50 gradient plus raising of a *Watt* (contour ridge) on its outer periphery.

ii. Watbandi: raising of *watts* on the outer periphery of each field on gentle gradients up to 1 in 50, but further levelling unnecessary.

Techinque and Procedure:—

i. Sequence of work:—This measure of land improvement (whether—terracing with or without *watting*) should, always begin from the top of a catchment and proceed downwards; otherwise, runoff from the untreated fields above would burst the *watts* and demolish the terraces below.

ii. Layout:—The field should lie lengthwise along the contour and breadthwise along the slope. The gentler the gradient, the broader can the field be. Length along the contour as long as possible, but the width along the slope should not exceed 50 feet.

iii. Watting:—The object of the peripheral ridges (*watts*) is to restrain the rain from pouring down the slopes and to conserve the same in the fields. Terracing is not efficacious unless supplemented by invulnerable *watts.* Conversely, the effect of *watting* decreases with the increasing slope of the field. *Watts* must be stout enough to withstand the force of stagnant as well as moving water in the field. The more sandy or friable the soil, the stouter should the *watt* be. Also, the broader the field along the slope and the steeper the gradient, the stouter should be the *watt.* On loamy soil and moderate gradient the *watt* should be at least 3 ft. wide at the base and 1 ft. at the top and 1½ ft. high (*vide Fig. I, plate* 27).

All *watts* breached during the rainy season should be immediately repaired, so that the requisite moisture is conserved in the fields for sowing wheat. All *watts* should be planted up with *khabbal* (*Cynodon dactylon*) grass to prevent gradual wearing away duriug rains. And this may preferably be got done by observing *watt*-planting days with beat of drum.

iv. Choice between the two operations:—On slopes steeper than 1 in 50 gradient, level terraces with *watts,* and not mere *watbandi,* must be done in order that the required width of 50 feet of the field can be kept without fear of bursting of the lower *watt* along the contour. Washing down of soil in the field proceeds from the upper portion. Silt begins

* Paper presented at the Soil Conservation Circle Officers Conference, Punjab, held at Hoshiarpur on 19th to 21st November 1945.

to accumulate at the toe of the lower *vatt* and spreads up the field until the whole of it is levelled up, (*vide Fig. II, plate* 27).

v. *Terracing:*—As a rule, all unlevel land, howsoever slight the slope, should be levelled with a *karah* (bullock drawn earth-scoop) or bulldozer machine, if available. It is preferable to keep a slight reverse inward slope on a terraced field. This would allow the outer *watt* to consolidate before the rain water can begin to accumulate against, and exert pressure on it. The best season for terracing and *watbandi* is after the winter rains, up to the middle of April.

Drainage.—Where light sandy soils occur, rainfall is rapidly absorbed, and practically no drainage problem arises. But the prevailing soil in this tract is non-porous, being clayey loam and even clay. In such soils, there is danger not only of the heavy downpours stagnating on terraced and *watted* fields and so damaging *kharif* crops, but also of the *watts* bursting. In friable calcareous soil, the fields would sink through underground water action. To obviate all this, a field to field drainage system is imperative; and the natural drainage lines should be utilized to carry off the surplus storm water.

The main drainage channels should be protected by vegetation; brick lined outlets (*nakkas*) should be put up through the *watts* down the banks of high terraces; and *kacha* outlets thickly matted with *khabbal* grass in the case of low terraces, in order to drain off surplus storm water which cannot percolate rapidly, particularly on impermeable soils. This would prevent breaches in the *watts*, formation of gullies, subterranean scouring and damage to crops from standing water. (Where rats are troublesome it may be necessary to keep *watts* clear of all vegetation.) The masonry outlets and apron will consist of a single layer of bricks laid in mud or lime mortar and cement pointed on the outside, but the wall should be $1\frac{1}{2}$ bricks thick and cement plastered. Every outlet should have its mouth through the *watts* about 3 inches higher than the general level of the field, in order that an average depth of 3 inches of water may stay on the field for continued percolation after cessation of rain. An apron of brick-*bajri* may be laid at the foot of the outlet with a view to prevent gullying. It must, however, be borne in mind that the most important feature of remodelling of cultivated land should be the obliteration of minor drainage channels by a properly constructed system of terraces.

Extra bullock power.—Since bullock power is so limited in this tract as to render large scale terracing difficult, it is a pre-requisite to increase the bullock power. And for this purpose the well to do section of the *zamindars* may be persuaded to purchase extra bullocks for which *taccavi* loans should be given on the usual terms. These loans will be provided in the usual way by the revenue officer competent to do so. It will be stipulated that the recipient shall spend the loan money exclusively for this purpose, failing which the whole amount will be recoverable at once.

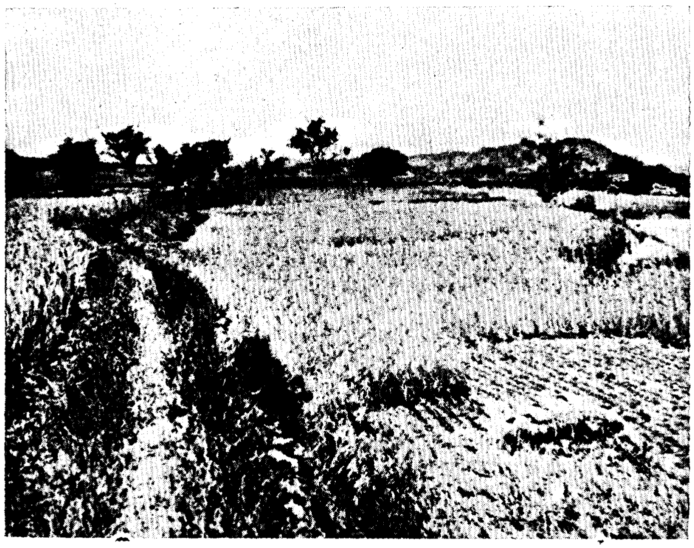
These *zamindars* will use the bullocks for terracing their own lands and also for lending to the smaller *zamindars* for the purpose on daily wages. These earnings and the financial aid which they would get for terracing their own lands (as provided hereunder), would go to pay back the loans. As a result of negotiations, the deputy commissioner has already received a grant of Rs. 20,000 for 1945-46 for the district; and the loans are being distributed in consultation with this department.

Escape Weirs.—Broad, shallow catchments can be reclaimed for cultivation by catching fertile silt behind an earthen *bund* provided with a masonry escape weir. This has been exploited most in Rawalpindi district.

The masonry escape should be so designed as to make it possible to raise its height gradually as silting proceeds behind the *bund*. This would ensure against the bursting of the weir. The *bund* should be strengthened and made invulnerable by planting of *Agave, sarut, nara* and *Ipomaea* along its toe and of *khabbal* grass on the sides and top (*vide Fig. III, plate* 28).

These weirs will serve to pass the storm water down the ravine at the lower extremity of the catchment area; and silt will

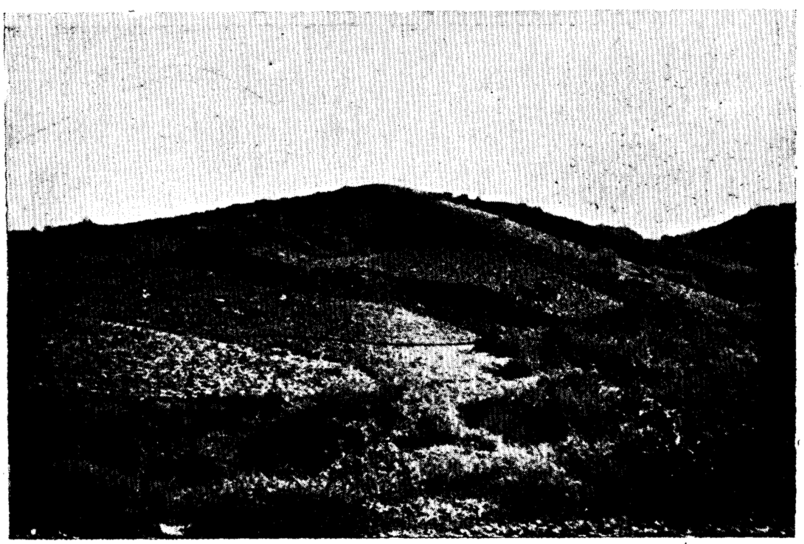
Fig. I



Good **wattbandi** on common land recently divided amongst individual owners and previously in a seriously eroded state.

Photo : R. M. Gorrie.

Fig. II



A Gujar tenant ploughing a 1 in 5 slope. The upper part of his field is already a deep gully but he ploughs in and out of this without attempting to block or level it.

Photo : R. M. Gorrie.

Fig. III.

Complete protection against erosion damage has been secured by this Ajnala landlord, Gujrat District, by good **watts** round every field and all old gullies smothered by tree and grass growth. This was previously waste so badly eroded as to be classed as unculturable.

Photo : R. M. Gorrie.

Fig. IV.

A small type of machine D4 filling in a hollow in order to complete the levelling of this new terrace. Pioneer work is being done in Gujrat district by an army unit while training their drivers.

Photo : R. M. Gorrie.

accumulate behind them up to a long distance on account of the gentle slope; and very fertile fields will be formed.

Policy and Agency of Execution of the Measures.

A. *Societies:*—There are two important considerations: the first is that the work should be carried out smoothly and in accordance with a set programme; the second is the setting up of machinery to ensure that the works, once they are completed, will be maintained in good order for ever. The *zamindars* must be disillusioned of any ideas about the government stepping in and doing everything for them, beyond the official initiative and drive. So far 15 soil conservation co-operative societies have been formed in this district.

Success depends on systematic work. It will therefore, be the responsibility of the society to organise systematically and to speed up the work. In the case of terracing and *watting* in particular, individual effort will in many cases not suffice, as frequently the efforts of one man to preserve and improve his fields are ruined by his negligent neighbour from whose untended fields storm water pours.

B. *Panchayats:*—The existing *panchayats* are expected to persuade the villagers into close co-operation as per the Panchayat Act. From our point of view they are an alternative to the society as a basis of organising the village as a unit for work.

C. *Consolidation of holdings:*—Fragmentation of holdings is a serious handicap both to the progress and efficacy of the land improvement measures which ought to proceed from top to bottom. So far only two villages—(Dilawarpur and Ajnala) in this tract are being tackled by the revenue department for consolidation.

D. *Compulsion:*—The amended Chos Act shall have to be applied to the lands of stubborn recalcitrants.

Progress of works and aid given for model work:—During 1940-41 to 1944-45 terracing with *watting* has been done over 14,967 acres and *watbandi* over 6,435 acres. Thus total area remodelled=21,402 acres. Out of this, financial aid to the extent of Rs. 10,367 has been afforded for model work done over 709 acres in demonstration areas @ 1/3rd of the estimated cost on terracing with *watts* and @ ¼th of that on *watbandi*. Besides Rs. 400 was contributed towards a masonry dam in Mohri village costing Rs. 2,700, Rs. 849 for drainage outlets and Rs. 817 for earthern *bunds* fitted with escape weirs.

For estimation of cost on terracing, a demonstration area of average soil over 5 acres was laid out in Kotla village in 1939-40, Labour (bullocks with *karahs* and coolies) was employed on muster roll on 50 : 50 basis on behalf of government and landlords under close supervision; and accurate figures of cost were maintained for the 3 plots separately. This gave cost figures per acre @ pre-war rates of Rs. 150 over steep gradient, Rs. 90 over moderate gradient and Rs. 40 over gentle gradient. These rates are higher than they need be owing to insistence of the owners on making very broad fields.

In assessing aid, only fresh work done during the year is taken into account, while the previously done old work is not aided. A journal has been maintained in each range, which shows for each demonstration area, year after year name of owner, field revenue number, total area of field, area of the field terraced or *wattbandied*, dimensions in *karams* of each field, estimated cost and financial aid afforded @ 1/3rd of the estimated cost for terracing with *watts* and @ 1/4th of that for *watbandi*.

Proposed aid on larger scale:—Without substantial aid, it is impossible to expect large scale work or even any appreciable progress in this most difficult land improvement. And that is why the *zamindar* too often neglects this work, even though he is well aware of its immense value. The aid suggested is very modest as below :—

(*i*) *Mere watbandi:*—No aid need be given.

(*ii*) *Terracing with watts:*—Besides the *taccavi* loans for increasing bullock power as mentioned above *taccavi* loans are also suggested to be given, free of interest and repayable after 15 years, to the individual *zamindars* at the rate of 2/3rds of the etsimated cost on work. In addition, 20 per cent of the estimated cost may be given as monetary reward on satisfactory completion of each

field. Both of these aids should be subject to the condition that the aspiring *zamindar* undertakes to complete satisfactorily all his lands within 10 years. The basis of repayment for work done by government owned bulldozers has yet to be determined.

(*iii*) *Masonry outlets* (*nakkas*):—The materials and skilled labour should be supplied by government, and the unskilled labour and sand by the *zamindars*. The *kacha nakkas* (escapes) will be made and planted with *khabbal* grass by the *zamindars* themselves.

(*iv*) *Masonry escape weirs* fitted to earthen bunds:—

The materials and masons should be supplied by government, and the unskilled labour, sand and earthen bund by the *zamindars*.

Outtern of work:—A pair of bullocks can do 330 cft. of earthwork daily with *karah* and plough, and a coolie can do 85 cft. A bulldozer (D8 caterpiller tractor with bulldozer or angledozer blade) can do 2,500 cft. of earthwork per hour or 15,000 cft. per day of 6 hours (*vide Fig. IV, plate* 28).

WARTIME PLANTATIONS IN DARJEELING DIVISION.

By A. Ali

(*Range Forest Officer, Bengal*)

Plantations in Darjeeling division were started about the year 1880. These are some of the earliest plantations in Bengal, if not in India. It is therefore surprising that the war emergency particularly from 1942 to 1945, enabled considerable improvement in the plantation technique in this region.

In 1942 as the war with Japan came to the eastern boundary of India the demand for defence timber increased enormously. Still greater was the demand for firewood and charcoal from the tea industry and from the increased number of military personnel and civil population in Darjeeling. A very larg, number of people, evacuated from Burma and from the coastal region of India, took temporary shelter in Darjeeling. The supply of coal and coke was considerably reduced due to their diversion to more urgent requirements in munition and other factories. The local government could not be uncharitable to the increased population and refuse them fuel in the wet and cold climate of Darjeeling. The working plan prescriptions were therefore shelved and unlimited fellings were permitted provided the sequence of fellings as laid down in the working plan was followed. In the Darjeeling hills, about 4 times the prescribed yield were clearfelled every year from 1942-43 in almost every felling series.

The forest d partment holds a great trust to posterity and no clearfelled area could be left blank. It had to be regenerated so that future generations may not be starved for lack of firewood. The nurseries were extended but it was impossible to enlarge them 4 times to produce sufficient stock to plant up the enlarged clearfelled areas.

The emergency thus caused was the mother of devising new means for artificially regenerating the clearfelled areas. It was a blessing in disguise because the new method has proved far more successful and much less expensive. It is true that plantations in these hills were started in the year 1880. But the older plantations consist very largely of *Cryptomeria* which grows like a weed in the hills. Even during the war, when any timber that could be sawn could be utilised, no use was found for *Cryptomeria* except as cork wood in small quantities. This species was therefore rightly condemned for good. The most valuable firewood species in these hills are the *buk* (*Q. lamellosa*) and *phalant* (*Q. lineata*). These species do not seed every year; they have such long tap roots that the seedlings cannot be successfully planted out after they are two years old. The most commonly used timber in these hills is *lali-kawla* (*Machilus odoratissima*) which seeds about once in five years. As luck would have it, this species also seeded profusely in 1944. The seeds of the oaks and *lali-kawla* were therefore extensively sown on small terraces in the plantation area.

The germination per cent was good and the young seedlings of *buk*, *phalant* and *kawla* could all be transplanted successfully

to other areas in the plantation which were not cleared early enough to enable the sowings to be done in time. The transplanting of oak seedlings with the cotyledons still attached to the roots was completely successful.

The technique consisted of the following:—

(*i*) The seeds were collected in November and December and buried in a ditch about 2 ft. under ground. The cost of collection of seeds amounted to Rs. 1-8 per md. of oak and *lali-kawla*.

(*ii*) The terraces were hoed along contour about 6 ft. long by 2 ft. wide and only about 6 inches to 9 inches deep. The seeds were taken out of the ditches, tested in water and sown immediately in the months of December to January. The cost of hoeing the terraces amounted to Rs. 4-11 per acre and of sowing them Rs. 2-5-6 per acre. The terraces were 6 ft. apart. In the *taungya* cultivation area, the forest villagers could grow their agricultural crop in the intermediate space but did the hoeing and sowing free of charge. The *taungya* cultivators did not however increase with the increased clearfelling. Darjeeling supplied so many men to the fighting forces and the labour corps that there was an acute shortage of labour. Large areas had therefore to be regenerated departmentally. In such areas *champ* (*Michelia*) seedlings were planted out in the intermediate spaces.

(*iii*) Germination started in April and continued for 4 or 5 months. Three cleanings were done in the first year. In June only the terraces were weeded at a cost of Rs. 2-8 per acre. Second weeding and cleanings were done in the 1st week of August, leaving the coppice shoots and saplings in between the terraces, at a cost of Rs. 3 per acre. Third weeding and cleaning over the whole area were done in October at a cost of Rs. 3 per acre.

(*iv*) In regenerating the unsown areas, first the seedlings from the terraces were used. Then seedlings from the terraces in the previous year's plantation were used. They were supplemented by nursery stocks of *champ* (*Michelia excelsa*), *kapasi* (*Acer campbellii*) and *pipli* (*Bucklandia populenea*.) Some walnut seeds were sown on suitable sites. Seedlings of *toon* (*Cedrela microcarpa*) were planted out at lower elevation.

(*v*) The whole area was planted out with *utis* (*Alnus nepalensis*), *saur* or birch (*Betula alnoides*) and *arupate* (*Prunus nepalensis*) 24′×24′ as a fast growing nurse crop to protect the seedlings from frost.

(*vi*) In the second year the seedlings in the terraces were thinned out to an espacement of at least 3 ft. apart to allow them to grow healthy and strong. The surplus stock was used in filling up vacancies and in the new plantations. Two cleanings were done in July and October.

(*vii*) In the third year also two cleanings were done in July and October.

(*viii*) Coppice shoots were allowed to grow freely all over the area to supplement the artificial regeneration which was established at the end of the third year.

The cost of the new technique, in spite of the enormous increase in the cost of labour, amounted to Rs. 31-14-6 in the first year against Rs. 37 for the older plantations, Rs. 5-8 in the second year in cleaning against Rs. 11-8, and Rs. 4-8 in the third year against Rs. 6 for the older plantations. The details are given in the statement appended. Thus, not only have more valuable species been grown in the war-time plantations of Darjeeling but about four times the prescribed area have been covered every year at a considerably reduced cost.

APPENDIX

COSTS PER ACRE

FIRST YEAR—

WARTIME PLANTATIONS (NEW)

	Rs. a. p.	Rs. a. p.
1. Cost of sowing seeds including making terraces:— Hoeing terraces and sowing seeds over 450 terraces @ three pies per terrace ..	7 0 6	
2. Cost of seeds:— After water-testing 2½ mds. seeds are required per acre, wastage in water test=½ md. total=3 mds. seeds @ Rs. 1-8 per md.	4 8 0	
	11 8 6	11 8 6
3. Nurse crop:— Collecting stakes, staking, making *thalies* and planting 80 seedlings @ three pies each	1 4 0	
Cost of 80 seedlings L.S. ..	0 10 0	
	1 14 0	1 14 0
4. Filling the intermediate spaces with 570 or 600 champ seedlings. Cost of seedlings @ Rs. 9 per 1200	4 8 0	
Making *thalies* and planting the above	5 8 0	
	10 0 0	10 0 0
5. 1st cleaning in June (only terraces were weeded) Rs. @ 2-8 per acre ..	2 8 0	
2nd cleaning, weeding done in 1st week of August @ Rs. 3 per acre	3 0 0	
3rd weeding in terraces and cleaning around them done in October @ Rs. 3 per acre ..	3 0 0	
	8 8 0	8 8 0
		31 14 6

OLD PLANTATIONS

	Rs. a. p.	Rs. a. p.
Cost of planting 1200 seedlings per acre, 6′×6′		
Cost of 1200 seedlings:— One *mali* can grow one lakh of seedlings in a year for which 83 *kamras* (12′×6′) are required. One *kamra* contains about 1210 seedlings ..		
Pay of *mali* for the year ..	420 0 0	
Proportionate Cost of one *kamra* ..	5 1 0	
Cost of mats	1 8 0	
Cost of manure	1 0 0	
Cost of seeds	1 7 0	
		9 0 0
Cost of cutting 1,210 stakes & staking them	5 8 0	
Cost of making 1,210 *thalies* & planting them	11 0 0	
Site cleaning for planting ..	3 8 0	
		20 0 0
Weeding *thalies* & cleaning during August @ Rs. 4 per acre..	4 0 0	
Weeding *thalies* & cleaning during October @ Rs. 4 per acre..	4 0 0	
		8 0 0
		37 0 0

WARTIME PLANTATIONS (NEW)	Rs. a. p.	Rs. a. p.	OLD PLANTATIONS	Rs. a. p.	Rs. a. p.
SECOND YEAR—					
Brought forward ..	31 14 6		Brought forward		37 0 0
1. 1st clearing during July @ Rs. 3 per acre	3 0 0		1. First clearing during May and filling up vacancies @ Rs. 6 per acre	6 0 0	
Second clearing, only the terraces were weeded during October, @ Rs. 2-8 per acre ..	2 8 0	5 8 0	Second clearing during August @ Rs. 3 per acre	3 0 0	
			Third clearing during October @ Rs. 2-8 per acre.. ..	2 8 0	11 8 0
THIRD YEAR—					
2. First clearing in July @ Rs. 2-8 per acre	2 8 0		2. First clearing during June and filling up vacancies @ Rs. 4 ..	4 0 0	
Second clearing (only the terraces were cleared in October) @ Rs. 2 per acre ..	2 0 0	4 8 0	Second clearing during September-October @ Rs. 2 per acre..	2 0 0	6 0 0
		41 14 6			54 8 0

SAVING OF COST IN THE NEW METHOD

FIRST YEAR—	Rs. a. p.	Rs. a. p.			
24 seeds of *buk*, *phalant* and *kawla* were sown in each terrace. In the first year 3,600 seedlings per acre were transplanted from these terraces which would have cost @ Rs. 9 per 1,200 seedlings	27 0 0		Nil		
In the second year 1,800 seedlings were transplanted which would have cost @ Rs. 9 per 1,200..	13 8 0	40 8 0	Nil		
Thus the ultimate net expenditure amounted to		1 6 6			54 8 0

AVERAGE RATES OF GROWTH

1st growing season height of the plants	1′-3″
2nd growing season height of the plants	2′-9″
3rd growing season height of the plants	4′-6″

ODE TO THE NOW DEFUNCT C. A. S. (BURMA) IN WHICH THE MAJORITY OF I. F. S. MEN IN BURMA SERVED

OUR JOE.

This is the tale of Major Joe
Whose habits were so very low;
He'd scrounge by day and pounce by night
And creep out again by dawn's first light,
Laden with loot he'd stagger back
But only to plan the next attack.
No mercy he'd show and his indents galore
Lay thick on the shelves and littered the floor
Till DADOS hadn't space for more
And even ALFSEA held him in awe.
When special ships were chartered it seemed
He'd at least achieved all he dreamed,
His fame and genius spread far and high,
Even the Yanks said "Gosh, some guy"!.
The local Burmans stared in wonder
At ten square miles of gorgeous plunder
And other units came to glare
With fury at the unfair share;
The stacks and stacks of packing cases,
Two hundred thousand pairs of laces,
A mass of stuff you'd never seen
And even salvage from the Salween.
Abundance reigned within the lair
Of food and trucks and English beer,
Of guns and socks and empty cans
Fifteen thousand frying pans.
At last he met his Waterloo
With lust to acquire something new
He'd inadvertently indented
(He surely hadn't really meant it?)
For bombs Atomic five hundred pound
But then this looked a bit unsound
The indent seemed a trifle thin
So a supplementary one went in.
The bombs arrived and Joe proceeded
To see if they were all he needed,
It didn't take him long to see
They came to pieces easily.
All Burma shook, the skies went dark
From Stalingrad to Richmond Park
With stores and mud and bits of Joe
Which fell around the place like snow.
The ghost of Joe can now be seen
Collecting coal and gasoline.

M. A. C.

VICTORIA'S FORESTRY PLAN *

AMBITIOUS SCHEME TO CONSERVE STATE'S TIMBER RESOURCES

The State Forestry Commission of Victoria (Australia) plans to embark on an intensive forest preservation and controlled management programme, spread over ten years, which will cost between Rs. 21,40,00,000 and Rs. 32,10,00,000.

Development of the scheme, which is to combine state planning with private enterprise, may take 20 years to complete, and will open up forest areas estimated to yield 6,000,000,000 super feet of merchantable timber worth approximately Rs. 64,20,00,000.

The smallest state on the Australian mainland, Victoria, has an area of 88,000 square miles. Twenty million acres of this is forest country, which places the state in the best forestry position in the commonwealth with the exception of Tasmania.

Of this area, 5,000,000 acres are reserved forest (including 4,000,000 acres of timber bearing areas and 1,000,000 acres of catchment area), 5,000,000 acres private property, and the remaining 10,000,000 acres timber bearing unreserved crown land.

Under the scheme, timber will come from the reserved forests and the unreserved crown land.

Although much of this forest country does not produce timber of milling quality, under proper management Victoria's forests will be sufficient not only to fill all the state's timber needs for all time, but to provide a surplus for export to less wooded states.

Timber for building and other purposes during the early postwar period, particularly in connection with the housing of returning service personnel, is urgently needed.

The demands of the fighting services and essential industry during the war years, together with the fact that imports of timber into Victoria during the same period fell from 142,000,000 super feet in 1938-39 to 60,000,000 in 1944-45, increased the drain on Victorian forests.

90 per cent Hardwood

In the past, Victoria has been particularly afflicted with bush fires, which took great toll of property, life and forests. It is estimated that the 1939 fires in Victoria killed 2,000,000,000 super feet of timber, although 1,000,000,000 super feet have since been salvaged. The average eucalypt forest takes 40 years to regrow.

Government interest in scientific forestry commenced in Victoria at the turn of the century, when a *Forestry Department* was established under a forestry controller. In 1919, a commission of three appointed by cabinet was set up. One member controls administration, while the two others attend to hardwood and softwood forests respectively.

Despite serious bush fires through the years, Victoria increased its timber output from 60,000,000 super feet in 1919 to 200,000,000 super feet in 1941-42. Of this latter amount, 18,000,000 super feet were softwoods.

Over 90 per cent of the timber trees of Australia consist of hardwoods belonging to the genus *Eucalyptus*, of which there are over 400 species. Only 50 are useful commercially however. In Victoria the predominant types of commercial eucalypts are mountain ash, messmate and stringy bark (Fig. I, plate 29).

As in other Australian states, Victoria aims to develop large softwood forests, and has already established 50,000 acres of pine plantations in the north and north-west of the state.

Under the new forestry scheme, mills and other forest product industries will eventually be centred in "timber townships" established at railheads instead of being scattered through the forests as at present.

In the townships will be concentrated workers engaged on making forest roads, doing silvicultural work and re-afforesting

* Release No. P/250 of the Public Relations Officer, Australian High Commissioner's Office, Delhi, exclusive to the *Indian Forester*.

cut out areas. Such communities will avoid exposing small groups of forest workers and their families to the dangers of fire, provide a readily available pool of fire fighters, and prevent pollution of watersheds. Townships will also provide educational, recreational and other amenities.

Cutting over of forest areas is to be strictly controlled in line with a policy of efficient management of timber resources. Between 4,500 and 5,000 men will be employed on the various aspects of the scheme, which will be developed at a spending rate of over Rs. 2,14,00,000 a year.

Preserving Asset

Planners are determined that this yield shall be based on the "wood interest" rather than the "wood capital" of the state.

They plan to achieve this by—

1. Fire prevention and protection.
2. The opening up of inaccessible mountain and watershed forests.
3. The orderly development and utilisation of forest products.
4. Re-afforestation to balance cuttings.
5. Preservation of watersheds.
6. Retention of forests in vulnerable areas to preserve soil cover and prevent erosion.
7. Preservation of beauty spots and development of scenic resorts for tourist purposes.

The first section of the scheme drafted by the commission as its two-year post-war programme has already been set under way. Approval for section to cost Rs. 3,38,00,000 already has been granted by the National Works Council, the authority controlling the balance of expenditure on major projects as between the various states of the commonwealth.

Aerial surveys have been made of the area, and survey gangs have gone into the bush to carry out further assessments. The work will be further extended as further officers become available from military service.

Fire-Fighting

Fire, the greatest devastator of forests, will be fought in the most intensive campaign yet launched by the commission. The campaign will be based on the provision of means of access, an elaborate spotting and communication systems, the use of modern fire-fighting apparatus, the employment of an army of men who can be rapidly assembled at threatened points, and the minimising of fire hazards (*vide* Fig. II, plate 29 and Fig. I, plate 30).

Water races, high level dams, concrete tanks and concrete retaining walls on creeks will be some of the many water conservation works used in this scheme. Roads and forest tracks will provide a strategic means of fighting fires and also offer facilities for the extraction of timber and for normal transport purposes. Army road- making equipment will be used.

Major road projects will include a through road 60 miles long and many miles of feeder roads reaching into areas of valuable timber. A major engineering undertaking will be a 16-mile road which will climb a 4,000 feet-high range in eastern Victoria.

Radio communication will play a big part in the fire prevention campaign. There are 80 transmitting and receiving sets ready for operation (Fig. II, plate 30). The control headquarters in Melbourne will be improved.

A big problem facing Victoria's forestry commission is the fact that the greater part of the timber killed by the 1935 fires was in the mountain ash belt, which is within 100 miles of Melbourne. Utilisation over the war period was largely from areas within this zone, including the fire killed areas. This means that accessible milling forests within reasonable distances of the Melbourne market have been seriously depleted, and many mills therefore will have to be transferred to other areas within the next five years.

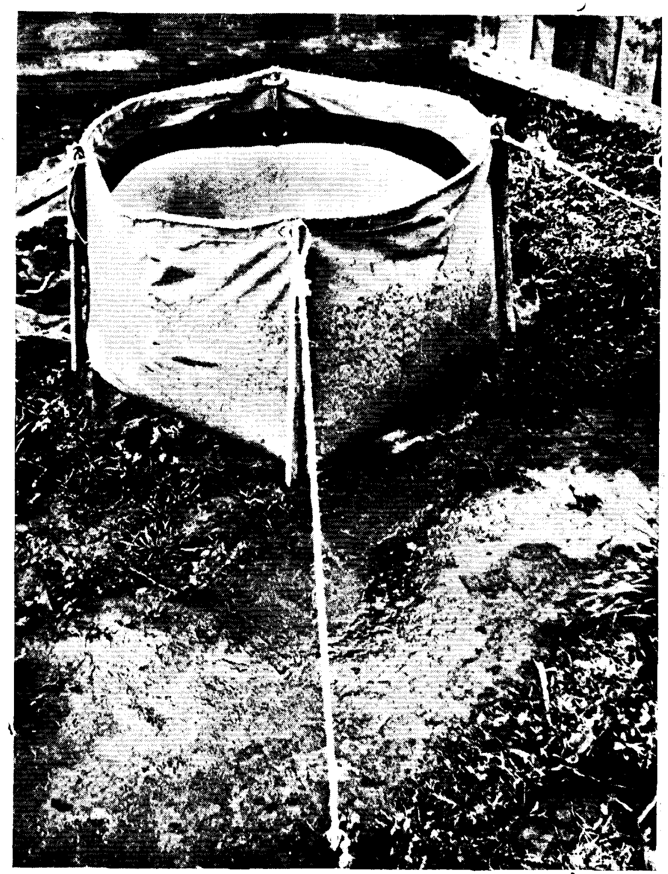
Available supplies of milling timber are now situated either in mountainous country within 150 miles radius of Melbourne, or in areas which are more accessible but another 100-150 miles further from the market.

Most of the timber in these mountainous areas is alpine ash, which provides high quality timber such as flooring boards, weatherboards, mouldings and joinery stock, which is at present in short supply. Scantling timber for building frames can be obtained from poorer quality foothill specimens.

Fig. I.

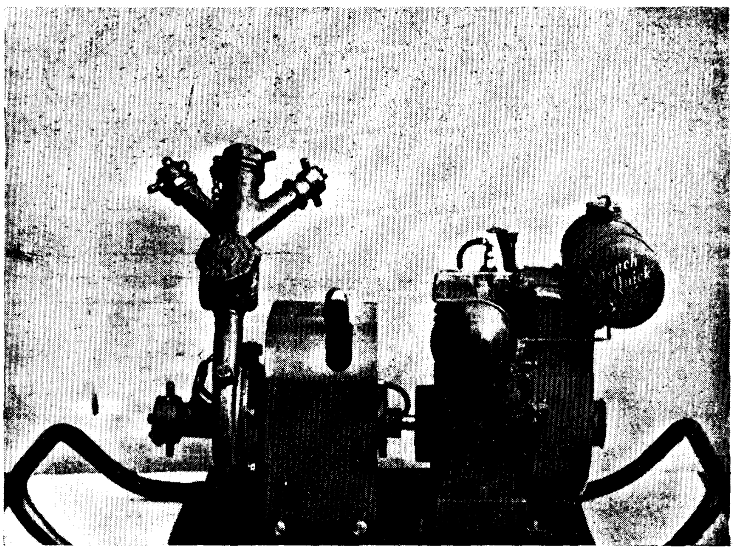
Example of White Mountain Ash found in the forests of Victoria (Australia). They are the largest hardwood trees in the world, some towering over 300 feet. Years ago, Victoria's pioneers cleared heavy forest country like this for farming purposes. Now the State is inadequately supplied with forests yielding large-sized timber within convenient distances of industrial centres.

Fig. II.



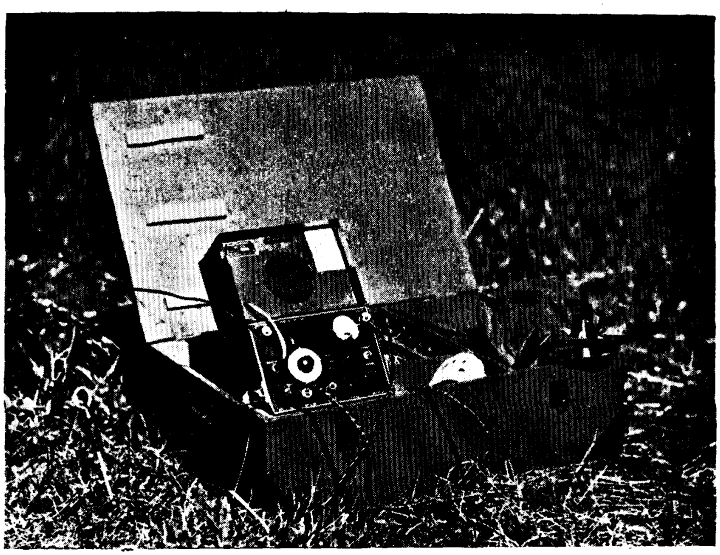
Seventy-five gallon canvas relay water tank used by Victorian Forestry Commission in combating bush fires. Water is pumped into tank, then on uphill through more hose by a second pumper unit.

Fig. I.



An Australian-made portable fire pump widely used by the Victorian Forestry Commission. Specially designed to meet Australian conditions, it bridges gap between manual means of fire-fighting and expensive high-powered pump. It uses a minimum quantity of water with maximum effect and weights only 85 lbs.

Fig. II.



A transmitter-receiver as used by Victorian Forestry Commission employees in combating bush fires. Equipment is portable and is carried in pack slung on one man's back. Pack contains instrument, two light weight batteries, hoist and two types of aerial. Range is 30 miles, total weight 35 lbs.

The commission has been handicapped in plans for the development of these areas by manpower difficulties—particularly the lack of trained technical staff such as engineers, engineering surveyors, draughtsmen, assessors, surveyors and architects; and also technicians such as tractor and bulldozer operators and skilled road foremen.

In order to put the commission's plans into effect, it will be necessary to increase greatly the commission's supervisory staff. Plans to this end have been drawn up which include provision for the training of additional administrative, technical and supervisory field staff, and recruitment of ex-servicemen for these classes of work.

TAUNGYA CULTIVATION AND ITS EXTENSION TO PLANTATION WORK.

By A. S. N. Murty

(*Special Ranger, Koraput District, Orissa*)

Shifting cultivation known as *podu* in Telugu, *bewar* in Central Provinces, *jhum* in Assam, and *taungya* in Burma, is the world's oldest method of agriculture still followed in many parts of hilly tracts wherever it is permitted. The main features of this system are the clearfelling of the forest growth on hill slopes by the end of January—even large trees are cut. Early in April the felled jungle which is now sufficiently dry, is burnt. After the first firing half burnt branches are collected in heaps and completely reduced to ashes. *The ashes are not distributed over the soil* before the seed is sown. Charred trunks are left where they lie until the following year when they are burnt together with the lopped shoots before the sowing of the second year's crop. The preparation of the hill slope is generally completed by the beginning of May but sowing is deferred till the first showers of the monsoon moisten the parched earth when broadcasting or dibbling of the seed of various grain crops such as *ragi* (*Eleusine coracana* Gaertn.), red gram (*Cajanus indicus* Sprang), *cambu*, *kharasa*, *judungo*, *bails*, *kangu* (*Setaria italica* Beauv.), *castor khosala*, and *korra* is done in the soil prepared without the help of a plough. After a period of cultivation ranging from one to four years the land is abandoned and not taken up again until the trees have grown sufficiently to admit of a second felling. This process continues until the land gets washed so bare of soil and seed that no more forest growth is possible and there remains a bare hillside useless for any purpose, producing thorns and coarse grass.

This primitive method is incompatible with the principles of forest conservancy. Yet it is one of the most striking successes of forestry wherever it has been systematically followed. This destructive practice has been successfully turned into a method of plantation so cheap and successful that of late it has been intensively introduced into tracts where it had died out or was put down at an earlier stage.

Taungya plantation procedure depends on getting the cultivator plant or sow a new forest crop with his food crop so that when he moves out useful trees, and not weeds, restock the areas. The starting of *taungya* is by far the most difficult period. Its success depends upon conditions such as existence of sufficient land for cultivation over a long period of years, existence of land hunger whereby people are forced in a natural way to take up this method like good contented cultivators, exercise of *tact and patience by the subordinate staff*, offering lenient terms and helping the cultivators in every reasonable way in the beginning till the system has properly established. The work has to be started in areas likely to be most successful from the forest point of view and in places most likely to be familiar to the cultivators.

The object of this system is to convert the existing miscellaneous worthless forests into valuable forests. The miscellaneous forests are leased out to intending cultivators free of rent as service *jagir* for two or three years and the cultivators enter into an agreement with the owner for fulfilment of the conditions prescribed. It is binding

both on the lessor and the lessee to abide by the conditions of the agreement. Under this agreement the cultivator clearfells the forest crop on the area assiged to him free of charge and enjoys the outturn provided he may not sell, give away or barter the same and burns it before the end of April. After the first monsoon showers break up the land, he cultivates it with any field crop and also sows the seed of any valuable forest species or plants out seedlings from the nursery—the planting distance adopted . generally being 12 feet×6 feet. The cultivator also tends the seedlings and plants by keeping them free of weeds, replaces failures, presents grazing and protects the crop from other dangers natural or artificial during the period he cultivates the land and just before moving on to a new area hands over the old area with a seedling crop of two or three years old to the forest department.

The area of *taungya* plantation which can be efficiently dealt with by one family of cultivators varies with the locality, but ranges between one to five acres.

The chief advantages of this system are that

(*i*) it gets over labour difficulties;
(*ii*) from the financial point of view it is cheaper; and
(*iii*) it tends to bring about cordial relationship between the forest department and the village folk.

The system can, however, be criticised for involving clearfelling and burning with consequent exposure of the soil; that the agricultural crop robs the soil much of its accumulated fertility which should go to the new tree generation and that the working of the soil and clean weeding between the lines result in an increased surface erosion. But these disadvantages are not so serious as to come in the way of progressive and successful work and the advantages, though few, far outweigh the disadvantages.

EXTRACTS

INDIAN PLANTS LIABLE TO PRODUCE DERMATITIS

By R. L. Badhwar, S. L. Nayar and I. C. Chopra

Medicinal Plants and Food Poisons Inquiry, Imperial Council of Agricultural Research, Drug Research Laboratory, Jammu Tawi.

There are a number of plants which are capable of producing irritation of the skin. This may be brought about by contact with the skin as in the case of some species belonging to the genera *Rhus*, *Holigarna*, *Urtica*, etc., resulting in minor or temporary irritation of the skin or painful irritation and inflammation with vesicles or blisters, depending on the severity of the contact and the susceptibility of the individual. Further, there are certain plants, such as *Fagopyrum esculentum* Moench., *Hypericum perforatum* Linn., etc., which, if ingested by certain livestock under certain conditions, lead to a photosensitization and consequent dermatitis of the unpigmented portions of the skin. Dermititis may, therefore, be either produced by contact with irritant

substances produced by the plant or by ingestion of the plant itself. An important point to remember in the case of these plants is that a number of them produce dermatitis only occasionally in individuals who are especially susceptible to them. Others are more troublesome and cause dermatitis in many, but not all, individuals who may come in contact with them or eat them.

The spines and thorns of a number of plants are also capable of entering the skin and setting up irritation. In some cases when the punctures so formed in the skin become subsequently infected with harmful micro-organisms serious septic wounds may be produced. Such plants are found in abundance in India, but obviously the injury they inflict is mechanical and hence they cannot come under the category of poisonous plants. They are, therefore, excluded from the scope of the present paper. On the other hand, the hair on the pods of some species of *Mucuna* have more or less a mechanical action in producing irritation; these have been included in this paper. The reason is that unlike the sharp spines which produce merely mechanical injury they produce prolonged irritation and itching due possibly to the presence of certain chemical substances. It has been considered desirable, therefore, to draw attention to the existence of such plants the irritation produced by which very closely resembles that produced by stinging nettles.

In India approximately 76 plants occur which are capable of producing dermatitis in susceptible individuals. In some cases their action is explicable by the presence of irritant substances produced by the plants, in other cases the phenomenon is not yet fully understood. The following are some of the important types of plants which may injure the skin and which are usually met with in this country :—

(1) *Rhus type where the juice of plant comes in contact with the skin and produces dermatitis:* Sollmann [1936] writing about some of the foreign species of *Rhus* says "Contact with certain species of *Rhus* common along roadsides, on fences, in woods and swamps, etc., produces typical dermatitis passing through the successive stages of hyperemia and itching, to violent vesication, edema, and suppuration, according to the specific sensibility of the individual; many persons are practically immune, although a sufficient quantity of the isolated toxicodendrol has never failed to produce the dermatitis.

"The active ingredient of all the species is a phenolic oily resin, toxicodendrol, contained in the sticky sap of the plants, which exudes when the plant is injured. It is identical or very similar in all the toxic *Rhus* species. It is so highly active that 1/1,000 mg. has caused severe vesication. Toxicodendrol is not volatile, but it may be conveyed to some distance on the soot in the smoke of burning plants, and perhaps on dust, and by insects alighting on injured plants. None is present in the pollen, as has been claimed. It may be conveyed by the hands or clothing from one person to another, as if it were contagious." Travellers in the Himalayan forests often hear some of the villagers having almost similar belief regarding the Indian species of *Rhus*. They would not touch the *Rhus* trees or have anything to do with them; some of them actually avoid even passing under them. Even the smoke, smell or sight, they say, will cause swelling and vesication of the skin. And yet it has been observed that many individuals are immune to these plants. To a lesser extent species of *Holigarna* are similarly dreaded in India. Such cases of poisoning may be treated thus: After contact the exposed part may be freely washed with some alkaline solution. A 5 per cent solution of ferric chloride or ordinary soap solution is best used for the purpose. Before exposure, use of this measure may prevent the manifestation of harmful effects. Local application of baking soda or Epsom salts, one or two teaspoonsful to a cup of water, or a 5 per cent solution of potassium permaganate may relieve the pain caused by inflammation. Fluid extract of Grindelia, diluted with 6 to 10 parts of water, is recommended for preventing the spread of inflammation. Ointments containing fatty or oily substances should not be used as the poison is soluble in oils and will, therefore, spread over other parts. Such emollients may, however, be applied as soothing agents after the poison has been thoroughly washed away. It has been found by experiment

that a certain amount of tolerance to the toxic effects of this plant may be developed in man by giving *per os* small and increasing doses of an alcoholic extract made from the plant to susceptible individual. Attacks of dermatitis in man caused by these plants may be prevented by subcutaneous injection of the alcoholic extract. The immunity produced by this method, however, does not persist longer than one month [Schamberg, 1919].

Important families which include plants whose juices are harmful are Anacardiaceae, Asclepiadaceae, Araceae and Euphorbiaceae. Species of *Semecarpus*, *Rhus*, *Holigarna*, *Excoecaria*, *Euphorbia*, *Calotropis*, *Arisaema*, etc., are the well-known examples in the point.

(2) *Urtica type where apparently the stiff hairs on the plant are responsible for producing dermatitis:* Urticaria produced by contact with the hairs on the stinging nettles, such as species of *Urtica*, *Girardinia*, *Laportea*, *Fleurya*, *Tragia*, etc., is well known. This urticaria is an inflammatory disorder accompanied by a considerable burning and itching in the affected part. The rash may come out in large or small patches, remaining for a few minutes or several hours and may disappear quite abruptly. It usually leaves no trace behind. *Laportea crenulata* Gaud. is perhaps the worst of all stinging nettles found in India. Contact with its hairs produces severe burning pain which may last for several days and is said to be greatly aggravated by the application of water. The sting is particularly powerful during the flowering season when it is said to bring on violent sneezing, sleeplessness and fever, hence the local English names (Fever nettle, Devil nettle) by which the plant is known to coffee planters. According to Haines [1921–25] the plant is quite innoccuous at some times of the year. This may be so on account of the hairs being deciduous, and that they are especially abundant on the inflorescence, but we have never found the plant to be entirely harmless at any time. Haines remarks that while cutting coupelines in November in the Sikkim Terai, where it is sometimes gregarious, his coolies were attacked with sneezing, violent catarrh and ultimately vertigo, apparently from inhaling the numerous minute hair. Out of all these stinging nettles the mechanism of producing dermatitis in the case of *Urtica dioica* Linn. is well understood, and it is likely that others may resemble this plant to a greater or less degree. What happens in the case of *Urtica dioica* is that the very fragile ends of the hair penetrate the skin and get broken off. The irritating principle from inside the hair is brought in contact with the tissues and the uncomfortable itchy sensation accompanied by nettle rash supervenes. It has generally been accepted that the irritating material in the stinging hairs of this plant is formic acid, but investigation by Cleery [1927] has thrown a considerable light on the subject. According to this author the protoplasm of these hairs has an alkaline reaction, and encloses an acid cell sap. The cell sap contains a small amount of formic acid as well as acetic butyric, and other volatile fatty acids. The specific poison of the cells, which is a non-volatile substance of an acid nature allied to the resin acids, is in solution in these acids. It is neither formic acid, nor probably an enzyme, or a toxalbumin. According to Cleery [1927] it is without doubt allied to the irritant substances found in some Primulaceae, Anacardiaceae and allied plants.

A popular remedy against the stings of these stinging nettles is to rub over the affected part the leaves of *Rumex nepalensis* Spreng. and *R. orientalis* Bernh. which are commonly met with and are often found near the nettles. They afford substantial relief, but if these are not available one's own saliva rubbed in is quite effective. Dilute ammonia is a good remedy and if available should be rubbed in over the affected parts.

(3) *Photosensitization caused by the ingestion of plants*: Some plants, such as *Fagopyrum esculentum* Moench. and *Hypericum perforatum* Linn., if ingested under sertain conditions and stages of growth, are capable of producing photosensitization and consequent dermatitis of unpigmented portions of the skin. All kinds of stock and laboratory animals which have an unpigmented skin and which are exposed to sunlight after the ingestion of the plant are liable to get this condition. Animals having pigmented skins or those not exposed to bright sunlight do not develop any symptoms. Photosensitization can be prevented by (*a*) feeding these plants to stabled animals only and discontinuing the feeding about a

month before animals are sent out to graze; (*b*) allowing such animals to graze in the early morning, late afternoon and at night only; and (*c*) by covering or staining albinos and white parts of pigmented animals. When the animal is actually affected feeding must be discontinued at once. The animal must be immediately shaded and a purgative given. Symptomatic treatment should also be applied. Among human beings, certain individuals are known to be sensitive to buckwheat which comes under this category. Severe itching is experienced and a rash is produced after eating food made from buckwheat flour.

(4) *Miscellaneous*: Some plants, such as *Xanthium strumarium* Linn., produce dermatitis only in very few individuals who are sensitive to this plant and that too only at the pre-fruiting stage. This has been observed in the case of our own plant collector who has often suffered by contact with this plant. The poisonous principle responsible for this action is not known. In other cases, such as in *Lasiosiphon eriocephalus* Decne. contact with the plant under natural conditions does not usually produce dermatitis. The dust from dried plants produces smarting of the eyes and mucous membranes and even of the intact skin.

Essential oils contained in the plants are sometimes responsible for irritating the skin, such as in the case of *Erigeron canadensis* Linn. and *Ruta graveolens* Linn. The resin from the rootstocks of *Podophyllum hexandrum* Royle is capable of producing severe irritation of the eyes and the mucous membranes generally. There are in addition a number of plants the exact mechanism of whose action or the active principles responsible for producing dermatitis are not yet fully understood. Research could be profitably undertaken on these plants so that rational treatments may be evolved against their injurious effects.

Below is given a list of plants occurring in India, which have been responsible for producing dermatitis. Their English names, common vernacular names, distribution, part or parts responsible for this condition and their chemical constituents and other general information, so far as these are known, are indicated for each species.

We are grateful to Col. Sir Ram Nath Chopra, C.I.E., for the valuable help and advice he has given us.

The following are the abbreviations used for the vernacular names:

Be.—Bengali; *Bo.* Bombay; *Hi.*—Hindi; *Kash.*—Kashmir; *Kum.*—Kumaon; *Ladd.*—Laddakh; *Lep.*—Lepcha; *Mal.*—Malayalam; *Mar.*—Marathi; *Nep.*—Nepali; *Pers.*—Persian; *Pun.*—Punjabi; *Sans.*—Sanskrit; *Tam.*—Tamil; *Tel.*—Telugu.

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
1. *Abroma augusta* Linn. *f.* English— Devil's Cotton Vernacular— Hi. & Be.—*Ulatkambal*; Bo.—*Ulaktambal*	A shrub, native or cultivated, throughout the hotter parts of India from the North-West India to Sikkim at alt. of 3,000 ft.; Khasia mountains at altitudes of 4,000 ft. and Assam.	....	Irritant hairs
2. *Ailanthus altissima* (Mill). Swingle (Syn. *A. glandulosa* Desf.) English— Ailanto, Chinese sumach, Japan varnish tree, Stinking cedar, Tree of the Gods, Tree of heaven	A large deciduous tree met with in the hills of Northern India, most probably introduced from Japan.	The flowers contain an essential oil (Isaev, 1932) The bark contains 0·005 per cent of a very bitter crystalline substance named ailanthin and probably also a glucoside and a saponin (Wasicky and Orien, 1933].	Leaves, flowers

Name of plant	Distribution	Constitutents	The part or parts of the plant which cause dermatitis
3. *Anacardium occidentale* Linn. English— Cashew nut, Cashew apple Vernacular— Hi. & Bo.—*Kaju*: Be.—*Hijli badam*	A small tree originally introduced from South America; now established in the coastal districts of South India, Chittagong, and the Andaman Islands.	The cellular pericarp is full of a black, caustic, oily juice which is a powerful rubefacient and vesicant. It contains the phenolic compound cardol, anacardic acid and an ether-soluble substance to which cantharidin-like effects of the oil are attributed [Joseph and Sudborough, 1923].	Juice from the pericarp and trunk is very caustic and produces blisters. The nut within which is the kernel (the cashew nut) must be roasted to get rid of the poisonous substance. The fumes arising from their roasting are very irritating.
4. *Anagallis arvensis* Linn. English— Bird's eye, Red chickweed, Shepherd's calendar, Shepherd's delight Vernacular— Hi.—*Jonkhmari*	An erect or procumbent annual found over the greater part of India ascending to an altitude of 8,000 ft. in the Himalayas. The red-flowered variety is found in Kashmir, but the blue-flowered one is more common in India.	The herb [Wehmer, 1929–31, *Supplement* 1935] contains two glucosidic saponins while the root contains cyclamin which is also a glucoside.	Leaves
5. *Anthemis cotula* Linn.	A foetid-smelling, acrid, erect annual herb found in Baluchistan and probably in Sind also.	The fresh plant yields 0·01 per cent and fresh flowers about 0·013 per cent of an essential oil [Hurd, 1885; Haake, 1891].	Leaves and flowers
6. *Apium graveolens* Linn. (wild form) English— Celery, Marsh parsley Vernacular— Hi. & Sans.—*Ajmoda*; Be.—*Chanu*	A biennial herb found at the foot of the North-West Himalayas and outlying hills in the Punjab. It is cultivated in different parts of India during the cold weather chiefly as a garden crop in the vicinity of towns for use as a salad and as a potherb. Sometimes it is cultivated in Bengal for its seed and in the Punjab for its roots.	The herb contains the glucoside apiin [Van Rijn, 1931] and an essential oil. The tubers contain very little of this oil but fruits contain 2·0 to 3 per cent.	According to Watt [1889–96] and Pammell [1911] the plant is irritant. Muenscher [1939] states that leaves are irritant.
7. *Arisaema speciosum* (Wall.) Mart. Vernacular— Pun.—*Kiralu, Samp-ki-khumb*	A herb found in the temperate Himalayas, from Hazara to Sikkim and Bhutan at altitudes of 7,000 to 10,000 ft.	...	Juice, especially from tubers
8. *Arisaema tortuosum* (Wall.) Schott. Vernacular— Pun.—*Don, Kiri-ki-kukri*	A tall plant found in the temperate and subtropical Himalayas from Simla to Bhutan at altitudes of about 8,000 ft., also in Khasia Hills, Manipur, Chota Nagpur, Ranchi and Parasnath. In Western India it is found in Konkan, and in the Madras Presidency in Rampa Hills at 4,500 ft., Horsleykonda at 4,000 ft., and in Western Ghats at 3,000 to 7,000 ft. above sea level. According to Duthie [1903-29] the Dehra Dun plant which is found at altitudes of 3,000 ft. differs considerably from the typical *A. tortuosum* of Schott.	....	Juice, especially from tubers

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
9. *Asparagus officinalis* Linn. English— Asparagus, Sparrow grass Vernacular— Hi.—*Halgun*; Be.—*Hikuna*	....	....	Young stems [Muenscher, 1939].
10. *Calotropis gigantea* (Linn.) Dryand. Vernacular— Hi.—*Ak*; Sans.—*Arka*; Be. & Bo.—*Akanda*	A stout shrub frequently met with throughout India as a weed on fallow land and in waste ground except in the Punjab where it is sometimes found in gardens only (Fl. Brit. Ind. mentions the plant as occurring in the Punjab, but this seems doubtful to us).	The fibre of this plant contains a toxic bitter substance. The juice contains a proteolytic enzyme similar to papain [Basu and Nath, 1933; 1936]. The roots contain a gutta-percha-like substance (madar alban) consisting of isovaleric esters of two alcohols, and also a bitter yellow resinous substance [Sharma, 1934; Hill and Sarkar, 1915].	Milky juice. Its action *is particularly severe on* mucous membranes.
11. *Calotropis procera* (Linn.) Dryand. Vernacular— Hi.—*Ak*, *Madar*, *Munder*; Sans.—*Alarka*; Bo.—*Mandara*	A shrub found more or less throughout India in warm and dry places from the North-West Frontier Province and in the Punjab to Western, Central and Southern India, it occurs abundantly in Sub-Himalayan tracts and the adjacent plains in the North-West.	The milky juice contains a proteolytic enzyme and a toxic substance [Gerber and Flourens, 1913]. It also contains a highly active resin [Gerber and Flourens, 1912]. The root bark contains a bitter yellow resin but no alkaloid [Sharma, 1934].	Milky juice. A child about three years old, accidentally during play, brought the juice in contact with his prepuce. He was brought to the hospital two days afterwards. The part was very much swollen and there were patches of ulceration with narcosis. The patient had difficulty in passing urine. On circumcision the glans penis was also found to be swollen and ulcerated.
12. *Cannabis sativa* Linn. English— Hemp Vernacular— Hi., Be. & Bo.—*Bhang*, *Ganja*; Sans.—*Gajika*	This plant is found in many parts of India on waste ground and by the roadside. In the Himalayas it grows wild and is widely distributed while it is acclimatized in the plains and is also occasionally cultivated.	The resinous matter (charas) found on the leaves, young twigs, bark of the stem and unfertilized flowers of the female plant contains about 1·5 per cent of a terpene, about 1·75 per cent of a sesquiterpene, a hydrocarbon monakosane and a toxic red oil, which is the active constituent of the plant. The approximate yield of the red oil is 33 per cent of the resin [Wood, Spivy and Easterfield, 1896; Marshal 1897].	*Leaves, flowers*
13. *Cissus setosa* Roxb. (Syn. *Vitis setosa* Wall.) English— Hairy wild vine Vernacular— Hi.—*Harmal*; Bo.—*Kahajgoli-charel*	A shrub found in Western India from the Circars and Mysore southwards	....	Juice

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
14. *Datura stramonium* Linn. English— Devil's apple, Jimson weed, Thorn apple Vernacular— Pun.—*Tottu dattura* ; Bo.—*Sada dhutura*	A coarse, annual herb found on the Himalayas from Kashmir to Sikkim up to an altitude of 9,000 ft. It is also met with in the hilly tracts of central and southern India.	The content of the alkaloid in the leaves varies from 0·3 to 0·5 per cent, the chief alkaloid being hyoscyamine. The bark, wood and pith of the stems contain 0·25, 0·09 and 0·20 per cent of the alkaloids respectively. The roots contain 0·1 to 0·25 per cent of alkaloids and the seeds 0·46 to 0·52 per cent [Feldhaus, 1905]. In some Indian specimens the total alkaloids in stems and roots vary from 0·19 to 0·26 per cent and in leaves and fruits from 0·38 to 0·43 per cent (Andrews, 1911).	Leaves, flowers, fruits
15. *Daucus carota* Linn. English— Carrot Vernacular— Hi., Bo., & Pun.—*Gajar*; Sans.—*Shikha-mulam*	A hispid biennial herb cultivated throughout India as an article of food.	The fruit of the cultivated carrot yields 1 to 1·5 per cent of an essential oil containing *l*-α-pinene, and a crystalline body named daucol (Finnemore, 1926). The leaves contain the two bases pyrrolidine and daucine (Pictet and Court, 1907) besides an essential oil.	It has been stated that some persons develop dermatitis on coming in contact with carrot leaves, especially when they are wet.
16. *Delphinium ajacis* Linn.	Cultivated in gardens	The seeds contain two alkaloids crystalline ajacin and crystalline ajaconin [Wehmer, 1929–31, *Supplement* 1935].	Leaves, seeds
17. *Dictamnus albus* Linn. English— Bastard dittany, Fraxinella, White dittany	A strong-smelling shrubby plant, met with on the temperate Western Himalayas from Kashmir to Kunawar at altitudes of 6,000 to 8,000 ft. ; very common in Pangi.	The roots contain an ethereal oil, a bitter substance, a saponin, a crystalline dictamnolacton (probably identical with evodin), a crystalline toxic alkoloid dictamnin and also a phenolic substance. The flowers contain 0·05 per cent and leaves 0·15 per cent of an essential oil [Wehmer, 1929–31, *Supplement* 1935].	Leaves, capsules
18. *Erigeron canadensis* Linn. English— Cobbler's pegs, Canada fleabane Vernacular— Kash.—*Kach*	An annual herb found in the Western Himalayas, Punjab and Rohilkhund up to an altitude of 4,000 ft. It is plentiful in certarn valleys in Kahmir. It is also found in Shillong (Assam) and on the Westen Ghats and Nilgiris up to 6,000 ft. above sea level.	Fresh leaves contain 0·33 to 0·66 per cent and dry leaves 0·26 per cent of an essential oil [Wehmer, 1929–31, *Supplement* 1935; Rabak, 1905]. Tannic acid and gallic acid have also been isolated from the leaf [Wehmer, 1929–31, *Supplement* 1935].	Leaves. The oil has an acrid taste and causes smarting of the eyes and soreness of the throat. The leaves produce irritation of the parts of the body coming in contact with the plant. When powdered the leaves produce a dust which is irritating [Pammell, 1911].

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
19. *Euphorbia acaulis* Roxb. (Syn. *E. fusiformis* Buch Ham.)	Found in the tropical Himalayas, Oudh, Bengal and western India.	....	Milky juice very acrid and vesicant
20. *Euphorbia antiquorum* Linn. Vernacular— Hi —*Tridhara-sehund*; Sans —*Vajrakantaka*; Be.—*Tekata sij*; Bo.—*Naraseja*	A large shrub or a small tree found in dry places throughout the hotter parts of India ascending to an altitude of 2,000 ft. It is also occasionally cultivated as a hedge-plant in villages.	....	Milky juice intensely irritant. During the collection of juice by the authors, the person employed for the purpose complained bitterly of itching all over the face, which was also considerably swollen. The trouble, however, was relieved by the application of a soothing preparation for a couple of days.
21. *Euphorbia cattimando* W. Eliot (*E. trigona* Fl. Brit. Ind., in part)	An erect shrub found on the dry rocky hills in the Deccan, and probably other parts of India.	Contains euphorbon (Henke, 1886].	Milky juice which is vesicant in fresh condition.
22. *Euphorbia helioscopia* Linn. English— Cat's milk, Sun spurge. Wartwort Vernacular— Hi.—*Hirrusecah*; Pun. *Gandal-buti*	An annual herb which is a common field weed in spring throughout the plains of the Punjab and the Siwalik tract, ascending to 8,000 ft. in the outer Himalayas. It is also found wild in the Nilgiris where it has been introduced.	The fresh herb contains a non-haemolytic saponin and also an acid saponin which is strongly haemolytic [Gonnerman, 1919] The seeds contain 32·6 per cent of a fatty oil the physiological action of which is due to a powerful purgative principle [Gillot, 1926].	Milky juice. Dymock [1884] reports a case of severe ulceration resulting from the application of a poultice made from the bruised plant.
23. *Euphorbia neriifolia* Linn. Vernacular— Hi.—*Sehund*; Sans.—*Snuhi*; Be.—*Massa-sij*; Bo.—*Mimguta*	A large fleshy shrub occasionally planted in villages as a hedge-plant throughout India and is sometimes found wild on waste land. In Orissa and in the Deccan it is said to occur in a state of nature in rocky places.	....	Milky juice is rubefacient and acrid
24. *Euphorbia nivulea* Buch-Ham. Vernacular— Be.—*Sij*; Bo.—*New-rang*; Sans.—*Pattakarie*	A large shrub or a small tree found in dry rocky places in Northern, Central and Southern India.	....	Milky juice
25. *Euphorbia peplus* Linn.	Probably an introduced species.	The herb contains 4·8 per cent of an oleo-resin [Vevey, 1908]. It also contains neutral and acid saponins with haemolytic properties [Gonnerman, 1919].	Milky juice
26. *Euphorbia rothiana* Spreng.	Found in Central, Western and Southern India,	....	Milky juice
27. *Euphorbia royleana* Boiss. Vernacular— Hi. & Pun.—*Shakar pitam, Thor.*	A fleshy shrub common on the dry and hot rocky slopes of the outer ranges of the Western Himalayas from the Indus to Kumaon, ascending to an altitude of 6,000 ft.; also on the Salt Range in the Punjab. It is also commonly grown in hedges in the Sub-Himalayan tract and the adjacent plains.	....	Milky juice. Very injurious to the eyes

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
28. *Euphorbia thomsoniana* Boiss Vernacular— Kash.—*Hirtiz*	It occurs in Western Tibet, Kurrum, Kashmir (Gilgit), etc., at altitudes of 10,000 to 12,000 ft.	....	Milky juice
29. *Euphorbi atirucalli* Linn. English—Milk, bush Indi an tree spurge Vernacular—Hi.—*Sehund*; Be.—*Lanka,—sij*; Bo.—*Shera*	An unarmed shrub or a small tree which is a native of Africa and has become naturalized in several places in India. It is often grown as a hedge or occasionally as a road-side tree.	The milky juice contains about 20 per cent of resins [Wehmer 1929-31, *Supplement* 1935].	Milky juice is rubefacient and vesicant. It produces severe inflammation and excruciating pain if it gets into a cut in the skin or into the eyes. It is said to be used by criminals to destroy the eyes of domestic animals.
30. *Euphorbia trigona* Haw. (*E. trigona* Fl. Brit. Ind., in part) Vernacular —Tel.—*Kattimandu*	An erect, glabrous shrub, found in the dry rocky hills in the Deccan.	The milky juice contains euphorbon, resin, rubber-like substances and malic acid [Wehmer, 1929-31, *Supplement* 1935].	Milky juice is acrid and in fresh condition is vesicant.
31. *Excoecaria agallocha* Linn. English—Blinding tree Vernacular—Be.—*Gangwa*; Bo.—*Gera*	A small tree found in tidal forests and swamps on all the coasts of India.	....	The fresh sap is extremely acrid and causes intolerable pain if it accidentally gets into the eyes, which sometimes happens to wood cutters when the tree is cut for fuel; hence the name 'Excoecaria'. It blisters the skin and produces sores.
32. *Fagopyrum esculentum* Moench. English—Buckwheat, Brank Vernacular—Hi.—*Kotu, Kaltu, Phaphra*; Pun.—*Darau, Phaphar, Obal*; Kash.—*Trumba shirin.*	An annual herb extensively cultivated in the Himalayas and Sub-Himalayan tracts and in Western Tibet at altitudes of 2,000 to 12,000 ft.; also in the Khasia Hills, Manipur, as well as in the hilly districts of Central and Southern India.	The herb contains the glucoside rutin, the seeds contain a substance which is toxic to lower animals [Ohmke, 1909]. The roots are said to contain oxy-methyl-anthraquinones [Maurin, 1925; 1926].	All parts of the plant, whether dry or fresh, are capable of producing photosensitization (fagopyrism) in animals, the fresh plant in the flowering stage being considered most toxic. The symptoms are : inflammatory swelling accompanied by severe itching of the ears, face and eyelids, spreading on to the sub-maxillary region and neck. In severe cases vesicles containing yellowish fluid appear on the affected part. These vesicles may become infected with bacteria and give rise to purulent and even necrotic dermatitis. Among human beings certain individuals are known to be sensitive to buckwheat. They experience severe itching and develop a rash from eating food made from buckwheat flour.

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
33. *Fleurya interrupta* Gaudich Vernacular—Hi.—*Lal bichua*	An erect herb found in Bihar, Central Bengal and Khasia Hills. In the Bombay Presidency it is met with in Konkan, Southern Mahratta Country and Kanara. In the Presidency of Madras it has been reported from the hills south of Mysore at altitudes of 5,000 to 6,000 ft. above sea level and also from the Rampa hills of the Eastern Ghats.	....	Stinging hairs on plant.
34. *Ginkgo biloba* Linn. English— Maiden-hair tree	Rarely cultivated in gardens. There is one tree in Amritsar.	The leaves contain five crystalline substances and also shikiminic acid. The seeds contain gingkol acid, two alcohols, ginnol and bilobol, and also asparagin [Wehmer, 1929–31, *Supplement* 1935].	Seeds.
35. *Girardinia heterophylla* Decne. The varieties *zeylanica* and *palmata* of the Flora of British India are now considered by several botanists as distinct species, viz., *G. zeylanica* Decne. and *G. leschenaultiana* Decne., respectively. *G. zeylanica* is found in the south-western hilly portion of the United Provinces and extends through Chota Nagpur, Mt. Abu, Konkan and the Deccan to the hills of Southern India and the west coast of Madras Presidency from 1,000 to 5,000 ft. above sea level. *G. leschenaultiana* is more restricted in its distribution and is found on the mountains of the Western Ghats at altitudes of 4,000 to 7,000 ft. Both these are known as Nilgiri nettles while the name Himalayan nettle is restricted to *G. heterophylla*. English— Himalayan nettle Vernacular— Hi.—*Alla, Bichua, Chichr*; Pun.—*Anjan, Bhabar, Karla.*	A perennial herb found in the subtropical and temperate Himalayas from Kashmir to Sikkim, up to 7,000 ft. above sea level, also in Assam and the Khasia Hills.	....	Stinging hairs on the plants.
36. *Hedera helix* Linn. English— Barren ivy, Creeping ivy, Ivy Vernacular— Hi.—*Lablab*; Pun.—*Banda* ; Kash.—*Karmora*	An evergreen, climbing shrub found in the Himalayas from 6,000 to 10,000 ft. above sea level and in the Khasia Hills from 4,000 to 6,000 ft.	Nearly all parts of the plant, viz., leaves, fruits and seeds contain the glucoside α-hederin and probably certain other glucosides [Van der Haar, 1912; 1913; Block, 1888].	Leaves.

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
37. *Hippomane mancinella* Linn. English— Manchineal tree	A much branched tree introduced from America, it is now occasionally cultivated in Indian gardens.	It contains acrid milky juice [Wehmer, 1929-31, *Supplement* 1935].	Milky juice
38. *Holigarna arnottiana* Hook. *f.* Vernacular— Bo.—*Bibu*	A tall tree found in the evergreen forests on the Western Ghats from the Konkan southwards.	....	Juice. In some persons it produces blisters, while others are immune. The tree is dreaded by the local people.
39. *H. grahamii* (Wight) Hook. *f.* Vernacular— Mar.—*Bilwuli, Bipte*	A tree found in Western India.	....	The juice has properties similar to those of *H. arnottiana.*
40 *H. longifolia* Buch.-Ham. *ex* Roxb. Vernacular— Be.—*Barola,* Bo.—*Hulugiri*	A tall tree native of Eastern Bengal and Chittagong.	..	The juice is of a powerfully caustic nature and blisters the skin.
41. *Humulus lupulus* Linn. English— Hops.	It is cultivated in the North-West Himalayas.	The active principles constitute the lupulin.	Leaves
42. *Hypericum perforatum* Linn. English— St. John's grass, St. John's wort Vernacular— Hi. and Pun.—*Bassant*	A perennial herb found in the Western temperate Himalayas from Kumaon between 6,000 to 9,000 ft. to Kashmir between 3,000 to 6,500 ft. above sea level.	The herb contains tannins and 0.065 per cent of an essential oil [Zellner and Porodko, 1925].	Several investigators have reported that the plant in the flowering stage, if eaten in large amounts by livestock, leads to a photosensitization and consequent dermatitis of the unpigmented portions of the skin. Animals having pigmented skins or those not exposed to bright sunlight do not develop any symptoms, but white-skinned horses, cattle and sheep develop characteristic symptoms (see under *Fagopyrum esculentum*) if exposed to sunlight. The toxic substance, it appears, acts upon the nerve-endings so as to photosensitize them and, if the animal is subsequently exposed to strong sunlight, it develops dermatitis, including blistering of the skin and falling off of the hair.
43. *Laportea crenulata* Gaudich English— Devil nettle, Elephant nettle, Fever nettle Vernacular— Hi.—*Utigun* ; Be.—*Chorpatta*	A stinging shrub or a small tree found in the tropical Himalayas from Sikkim eastward, also in Assam and the Khasia Hills. In the Madras Presidency it is found in the Western Ghats at altitudes of 1,000 to 5,000 ft. and in Rampa Hills at 2,500 ft. above sea level.	According to Smith [1923] the toxic principle is formic acid but the authors have not been able to confirm this by reference to original papers consulted by them.	Stinging hairs on plant. It is perhaps the worst of all the stinging nettles found in India. A contact with the hairs produces severe burning pain which may last for several days and is said to be greatly aggravated by the application of

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
			water. The sting is particularly powerful during the flowering season when it is said to bring on violent sneezing, sleeplessness and fever, hence the local English names (Fever nettle, Devil nettle) by which the plant is known to coffee planters and other English residents. Haines [1921–25] remarks that while cutting coupe lines in November in the Sikkim Terai, where it is sometimes gregarious, his coolies were attacked with sneezing, violent catarrh and ultimately vertigo, apparently from inhaling numerous minute hairs.
44. *Laportea terminalis* Wight	An erect herb found in the subtropical Himalayas from Kumaon to Mishmi at altitudes of 4,000 to 8,000 ft., in the Central Provinces at altitudes of 4,000 to 6,000 ft., and in the evergreen forests of the Western Ghats of the Madras Presidency at altitudes of 5,000 to 7,000 ft. It is also found in the Nilgiris.	....	Stinging hairs on plant.
45. *Lasiosiphon eriocephalus* Decne. English— Woolly-headed gnidia Vernacular— Bo.– *Rametha*	A shrub, sometimes a small tree, found in the open forests of the Western Ghats of the Bombay and Madras Presidencies, ascending to an altitude of 7,000 ft. in the Nilgiris.	....	The bark (and perhaps the leaves also) is powerfully vesicant. The collector of the bark for examination by the authors complained bitterly of a burning sensation in the eyes, nostrils and face during packing of the dried bark in bags. This sensation lasted, more or less, for three days.
46. *Leonurus cardiaca* Linn.	A herb found in temperate Western Himalayas from Kashmir to Kumaon at altitudes of 6,000 to 10,000 ft.	The herb contains an amorphous bitter substance leonurin [Wehmer, 1929–31, *Supplement* 1935].	Leaves.
47. *Lobelia excelsa* Lesch.	A herb which grows on the Western Ghats of South India, the Nilgiris, Pulney Hills and hills of Travancore at altitudes of over 5,000 ft.	....	Milky juice.

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
48. *Lobelia nicotianifolia* Heyne English— Wild tobacco Vernacular— Hi.—*Nala, Narasala;* Be.—*Badanala, Nala;* Bo.—*Bokenal, Dhavala*	A herb found on the Western Ghats from Bombay to Travancore at altitudes of 3,000 to 7,000 ft. above sea level and is met with in Konkan, the Deccan, the Nigiris, Malabar, etc.	The leaves contain two alkloids one of which resembles lobeline from *L. inflata* Linn. [Dragendorff and Rosen, 1886].	Milky juice. The dust from the powedered herb irritates the nostrils in the same way as tobacco.
49. *Mucuna atropurpurea* DC.	A woody climber found in the plains of Western India.	....	See *Mucuna prurita.*
50. *Mucuna gigantea* DC. English— Elephant cowitch Vernacular— Mal.—*Kakavalli;* Tam.—*Kalgaivalli;* Tel.—*Enugadulagondi*	A woody climber found in the plains of Western India.	....	See *Mucuna prurita.*
51. *Mucuna hirsuta* Wight & Arn.	An annual climber found in the plains of Western India.	....	See *Mucuna prurita.*
52. *Mucuna monosperma* DC. English— Negro bean Vernacular— Bo.—*Sonograri, Mothikuhili.*	A woody climber of the Eastern Himalayas and Khasia Hills, also met with in Assam, Chittagong, and the hills of Western India.	....	See *Mucuna prurita.*
53. *Mucuna prurita* Hook. (*M. pruriens* Fl. Brit. Ind., *non* DC.) English— Cowhage, Cowitch Vernacular— Hi.—*Kiwach ;* Sans.—*Atmagupta ;* Be.—*Alkushi ;* Bo.—*Kuhili*	An annaul cilmber found in the Himalayas and the plains.	....	The rigid, pointed hairs on the pods, if touched, enter the skin and produce itching. The action appears to be purely mechanical.
54. *Nerium oleander* Linn.	Rarely cultivated in gardens; a plant of the Mediterranean region.	The leaves contain the glucosides neriin and oleandrin.	Leaves.
55. *Podophyllum hexandrum* Royle (Syn. *P. emodi* Wall. *ex* Hook. *f.* & Thoms.) English— Ducks foot, May apple Vernacular— Hi.—*Papra ;* Kash.—*Banwangan ;* Pun.—*Bankakri*	A herb found in the interior ranges of the Himalayas at altitudes of 9,000 to 14,000 ft. from Sikkim to Hazara descending to 6,000 ft. in Kashmir.	The rootstock yields resin (podophyllin) and crystallised podophyllotoxin 10 per cent and 3.5 per cent respectively.	Rootstocks. Podophyllin greatly irritates the eyes and the mucous membranes generally. The collectors of this drug have to be very careful.
56. *Polygonum hydropiper* Linn. English— Biting pepper, Smartweed Vernacular— Be.—*Packur-mul*	A herb found in wet places more or less throughout India, ascending to an altitude of 7,000 ft. in the Himalayas.	The herb contains formic acid, acetic and baldrianic acid, much tannin and small amounts of an essential oil [Steenhauer, 1919]. The root is said to contain oxymethylantraquinones [Maurin, 1925; 1926).	The fresh plant contains an acrid juice which causes irritation and smarting when brought into contact with the nostrils or eyes. The bruised leaves as well as the seeds will raise blisters if employed as a poultice, as in the case of mustard poultice.

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
57. *Ranunculus sceleratus* Linn. English— Marsh crowfoot, Water celery Vernacular— Kum.—*Shim* ; Pers.—*Kabikaj*	An erect, annual herb met with on river banks in Bengal and Northern India, in the marshes of Peshawar and in the warm valleys of the Himalayas. It appears during the cold weather and remains until the break of the rains.	The plant contains anemonin, anemon acid and an essential oil [Wehmer, 1929-31, *Supplement* 1935].	Leaves. The fresh plant is highly acrid. The bruised leaves when applied to the skin raise blisters and were formerly used in Europe by professional beggars to produce or maintain blisters or open sores to excite sympathy.
58. *Rhu sinsignis* Hook *f.* Vernacular— Lep.—*Serh* ; Nep.—*Kagphulai*	A small tree found in the interior valleys of the Sikkim Himalayas at altitudes of 3,000 to 6,000 ft. and in the Khasia Hills at 4,000 ft.	....	Leaves, bark, fruit. The juice is a powerful vesicant.
59. *Rhus punjabensis* J. L. Stew. *ex*. Brand. Vernacular— Pun.—*Arkhar, Kakkrein, Titari*	A small or medium-sized tree found in the North-Western Himalayas at altitudes of 2,500 to 8,000 ft. from the Indus eastwards and is common in the inner ranges in moist ravines, etc.	....	Leaves, bark, fruit. The juice is a vesicant.
60. *Rhus succedanea* Linn. English— Crab's claw, Japan wax tree, Red lac sumach Vernacular— Hi. and Be.—*Kakrasingi* ; Bo.—*Takadasingi* ; Pun.—*Arkhol*	A medium-sized tree found in the temperate Himalayas from Kashmir to Sikkim and Bhutan at altitudes of 3,000 to 8,000 ft. It also occurs in the Khasia mountains between 2,000 and 6,000 ft., and in Sind.	The leaves contain about 20 per cent of tannin. The milky juice yields a lac similar to Japan lac with laccol, a toxic phenol. Laccol is identical with urshiol [Wehmer, 1929-31. *Supplement* 1935].	Leaves, bark, fruit. The juice is a vesicant.
61. *Rhus wallichii* Hook. *f.* Vernacular— Hi.—*Akoria* ; Nep.—*Chosi* ; Pun.—*Arkhar, Arkol*	A small tree found in the temperate Himalayas from Garhwal to Nepal, occurring at altitudes of 6,000 to 7,000 ft. above sea level.	....	Leaves, bark, fruit. The juice possesses vesicant properties.
62. *Rumex acetosa* Linn. English— Dock sorrel, Sorrel	A perennial herb met with in the Western Himalayas from Kashmir to Kumaon, at altitudes of 8,000 to 12,000 ft.	The plant contains oxalates as well as free oxalic acid (Berthelot and Andre, 1886 ; Fleury, 1889]. It contains acid potassium oxalate and some tartaric acid [Watt and Brayer-Brandwijk, 1932]. Purdie, [1927] found 1·36 per cent of potassium binoxalate in the juice. Maurin [1926] reports 1·05 per cent of oxymethyl-anthraquinone from the roots and traces of the same from the leaves.	Leaves produce dermatitis in susceptable persons.
63. *Rumex acetosella* Linn. English— Field sorrel, Sheep's sorrel, Sourack Vernacular— Be.—*Chukapalam* ; Sans.—*Chutrika*	A perennial herb found in the Eastern Himalayas in Sikkim at altitudes of 7,000 to 8,000 ft.	The herb contains oxalates as well as free oxalic acid. Also contains potassium binoxalates [Orlandini, 1933].	Leaves.

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
64. *Ruta graveolens* Linn. var. *angustifolia* Hook *f.* English— Common rue, Country-man's treacle, Garden rue Vernacular— Hi.—*Pismarum, Sadab;* Bo.—*Satap;* Be.—*Ermul, Ispund*	Occasionally cultivated in gardens.	An essential oil.	Leaves. If much handled they produce redness, swellings and even vesication of the part with which they come in contact.
65. *Sapium insigne* Trimen Vernacular— Hi.—*Khinna;* Bo.—*Dudla;* Pun.—*Bileja, Dudla*	A small or middle-sized tree found in the Sub-Himalayan tract and outer Himalayas from the Ravi eastwards to Bhutan (not in Sikkim) ascending to an altitude of 5,500 ft.; also in Assam, Chittagong and Orissa. In Western and Southern India it is common near the sea-coast of Konkan and North Kanara, and is also found in the Deccan, hills of Kurnool, Cuddapah and Nellore, Kambakam Hill in Chingleput, Western Ghats and West coast, and is usually found in rocky places up to 6,000 ft. above sea level.	....	Milky juice is acrid and acts as a vesicant.
66. *Schima wallichii* Choisy, Vernacular— Hi.—*Chilauni, Makusal*	A large evergreen tree of the Eastern Himalayas, from Nepal and Sikkim to Bhutan, found at altitudes between 2,000 and 5,000 ft. It also occurs in Assam, the Khasia hills and Chittagong.	Leaves contain saponin [Wehmer, 1929-31, *Supplement* 1935].	The bark, in which the liber cells appear like glistening white needles, irritates the skin in the same way as cowhage (*Mucuna prurita*).
67. *Semecarpus anacardium* Linn. *f.* English— Common marking nut tree Vernacular— Hi. and Be.—*Bhela;* Bo.—*Biba;* Sans.—*Bhallatamu*	A moderate-sized tree found in the Sub-Himalayan tract from the Beas eastwards, ascending in the outer hills up to 3,500 ft., Assam, Khasia Hills, Chittagong, Central India, Gujerat, Konkan, Southern Mahratta Country, Kanara and in deciduous forests of all districts in the Madras Presidency.	Earlier investigators suggested that the black corrosive juice of the pericarp contained a tarry oil consisting of 90 per cent of an oxy-acid named anacardic acid and 10 per cent of a higher non-volatile alcohol called cardol. Naidu, [1925] isolated catechol and a mono-hydroxy phenol which he called 'anacardol' besides two phenolic acids and a fixed oil from the kernel of the nut. Pillay and Siddiqui, [1931] were unable to find either anacardic acid or cardol or catechol and anacardol as reported by previous investigators. They	Juice from pericarp and the tree-trunk. It is a powerful counter-irritant and vesicant and has been used by malingerers for producing ophthalmia and skin lesions as also by others for imitating bruises in support of a false charge. Cases are known where the juice has been employed to cause injury to other persons.

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
		isolated the following constituents from the juice of the pericarp; (a) A mono-hydroxy phenol which forms 0.1 per cent of the extract, (b) an o-dihydroxy compound forming about 46 per cent of the extract, and (c) a tarry, non-volatile corrosive residue forming 18 per cent of the nut.	
68. *Semecarpus travancoricus* Bedd. Vernacular— Mal.—*Arukaram;* Tam.—*Shenkottal;* Tel.—*Natu sengota*	A very large tree found in the evergreen forests of Tinnevelly and Travancore up to an altitude of 4,000 ft.	....	Juice; properties similar to that of *S. anacardium*
69. *Tragia bicolor* Miq.	A slender climbing herb found in the Western Ghats, the Nilgiris and Pulney Hills at an altitude of 5,000 to 6,000 ft. in Shola forests.	....	Stinging hairs on plant
70. *Tragia involucrata* Linn. (with varieties in the Flora of Brit. Ind. which are now treated as distinct species, viz., *T. hispida* Willd., *T. muelleriana* Pax and Hoffm., *T. cannabina* Linn. *f.* and *T. montana* (Thw.) Muell-Arg. Vernacular— Hi.—*Barkanta;* Be.—*Bichuti;* Bo.—*Kanchkuri;* Sans.—*Vrishchikali*	A perennial twining herb found throughout India from the Punjab and the outer Himalayan ranges eastward to Assam, and southward to Travancore.	....	Stinging hairs on plant
71. *Urtica dioica* Linn. English— Common nettle, Stinging nettle Vernacular— Hi. and Pun.—*Bichhu, Bichhua*	An erect herb found in the North-West Himalayas from Kashmir and the Salt Range to Simla at altitudes of 8,000 to 10,700 ft. and in Western Tibet at altitudes of 8,000 to 12,000 ft.	The plant contains lecithin and a glucoside [Wehmer, 1929-31, *Supplement* 1935]. According to Cleery [1927] the protoplasm of hairs has an alkaline reaction, and encloses an acid cell sap. The cell sap contains a small amount of formic acid as well as acetic, butyric and other volatile fatty acids. The specific poison of the cells, which is a non-volatile substance of an acid nature allied to the resin acids, is in solution in these acids.	Stinging hairs on plant
72. *Urtica hyperborea* Jacq. Vernacular— Ladd.—*Dzatsutt, Stokpotsodma, Zatud*	A low, densely tufted under-shrub found in Western Tibet at altitudes of 12,000 to 17,500 ft. and in Eastern Tibet between altitudes of 16,000 to 17,000 ft.	....	Stinging hairs on plant

Name of plant	Distribution	Constituents	The part or parts of the plant which cause dermatitis
73. *Urtica parviflora* Roxb. Vernacular— Kum.—*Berain, Bichhu, Shishona*	A slender herb found in the temperate Himalayas from Kashmir to Mishmi between altitudes of 5,000 to 12,000 ft. The Flora of British India also records it from Ootacamund in the Nilgiris.	....	Stinging hairs on plant
74. *Uritica pilulifera* Linn. English— Roman nettle	A common European stinging weed occurring occasionaly near Simla and elsewhere near habitations in the hills.	The seeds contain a fatty oil and a glucoside [Wehmer, 1929–31, *Supplement* 1935].	Stinging hairs on plant
75. *Wallichia disticha* T. Anders. Vernacular— Lep.—*Katong*	A handsome palm of the outer hills of Sikkim	....	Berries and perhaps also the leaves [Watt, 1889–96]
76. *Xanthium strumarium* Linn. English— Bur-weed, Cocklebur Vernacular— Hi.—*Chhoat-gokru*; Be.—*Bon-okra*; Bo.—*Shankeshvara*; Sans.—*Arishta*	A herb throughout the hotter parts of India, usually near habitations ascending in the Western Himalayas to an altitude of 6,000 ft.	1·27 per cent of amorphous glucoside xanthostrumarin, etc., in seeds [Zander, 1881].	Leaves cause severe vesicular dermatitis in susceptible persons. Our plant collector is particularly sensitive to it. It is only, however, in the growing season that he suffers. In November when the plant is withering he is not susceptible.

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RETURNED SOLDIERS AND SOIL AND WATER CONSERVATION IN THE PUNJAB

R. MACLAGAN GORRIE, D. Sc., I.F.S.

Conservator of Forests, Soil Conservation Circle, Punjab, Lahore.

The Punjab is and probably will always remain predominantly agricultural; reconstruction must, therefore, centre round the land. The soil is the basic resource which we must foster and conserve to the best of our knowledge and ability. But at present many parts of India are drying up; the soil and water supplies are being wasted and it can safely be said that soil erosion and failure to conserve water are the twin causes of agricultural poverty.

The twin bogeys

If we are to secure good and happy prospects for the returning Punjabi soldier, the aim must be to deal effectively with these twin bogeys of agriculture. Those who have won decorations and perhaps a few other lucky men may get land allocated to them in one or other of the existing canal colonies or in such extensions of irrigation as are now being carried through. But a greater number of soldiers must depend upon the non-irrigated tracts for their future civilian livelihood, and it is in these *barani* tracts, dependent on a scanty and irregular rainfall, that the twin evils of soil erosion and scarcity of soil moisture have to be conquered. Just how this can be done has already been demonstrated effectively by the forest department in its soil conservation drive, but this work has so far been confined to comparatively small areas in the following districts: Ambala Hoshiarpur, Gurgaon, Kangra, Gurdaspur, Gujrat, Jhelum, Attock and Rawalpindi. Under a greatly enlarged programme of post-war reconstruction we plan to apply these same principles of conserving soil and water by control of grazing, contour *wattbandi* of fields, afforestation of waste lands and the reclamation of torrents, wherever this can be applied.

Reclamation work

The first item in the Forest Department's proposals is the reclamation of eroding cultivation and of ravined lands. Very large blocks of so-called *darrar* lands badly cut up by deep ravines have rendered cultivation impossible and the individual cultivator single-handed has often abandoned the struggle to save his land from the ever-spreading gully. A few instances of reclamation work carried out by co-operative societies under the guidance of the forest Department have shown that with proper guidance and co-ordination the community can save its own land. With the aid of earth-moving machinery such as the army is now familiar with, such work becomes correspondingly easier and quicker. Heavy earth-moving equipment consisting of bull-dozers, terracers, sub-soilers and other specialized equipment will be required and are being purchased abroad, but the army can also make suitable surplus machines available from war material, now that Japanese war is finished. The scheme is expected to reclaim 150,000 acres of now useless *darrar*, and to increase the productivity of a further 350,000 acres of poor and unterraced land already threatened with erosion. The areas in which large blocks of *darrar* land occur are incidentally those which have done best in recruitment, *e.g.*, Rawalpindi, Jhelum, Attock, Gujrat, Hoshiarpur and Ambala, so that whatever reclamation is effected, will be a direct contribution towards resettlement of the soldiers.

District Pioneer Companies

The manual labour required to complete the work of these machines can best be provided by the demobilized men themselves. It is proposed to form District Pioneer Companies which will retain each man's services until a dwelling place is ready and his land fit to till. These District Pioneer Companies together with a Provincial Headquarters Unit which would be responsible for the upkeep and working of the machinery could all be managed on a semi-military basis. A strong and efficient travelling workshop unit which could travel from district to district would be essential. The proposed Machinery Companies and the Auxiliary District Companies could be officered partly by technically

trained men who would control the field work in collaboration with the local Forest Department's staff, while the discipline, housing, rations and clothing will be looked after by military officers. In each district where this type of work is visualized and where District Soldiers' Boards are already established these should provide a nucleus around which the district organization can be built up.

Reclamation of waste lands

The next item in the Forest Department's programmé is the reclamation and improvement of waste lands to make them more productive in terms of timber, firewood, fodder grass, thatching grass, resin and gum extraction and the many other similar items of forest produce which can add to the villagers' income. In order to do this, however the one essential factor is the control of grazing. At present practically all the village waste land in the province is deteriorating and lapsing into treeless and unproductive desert owing to the incessant and persistent damage caused by uncontrolled grazing. Along the bed of every torrent, small stream and large river in the province there are vast areas of land now quite unproductive but, given protection from grazing and an energetic planting programme, such as has already been adopted by several hundreds of co-operative societies, these torrent-ravined lands can to a great extent be made productive. Particularly below the Hoshiarpur and Ambala Siwaliks these torrent beds are capable of producing several million tons of *sissoo* which is one of the best timbers in the world for general construction, furniture and agricultural purposes.

Management of avenue trees

The third part of this afforestation programme is the scientific management of all the avenue trees in the province whether they belong to the Irrigation Branch, District Boards or the Public Works Department. The recent so-called firewood famine need not have been so severely felt if these various departments and public bodies who own avenues had taken timely steps to make available to the towns many dead and dying trees in their avenues. Our object now should be to ensure that all waste land on the edges of roads, canals and railways is fully stocked with young trees, the watering and protection of which over many miles of land will of course require a considerable staff, but the return, which the Punjab will secure, cannot be expressed in terms of rupees alone, because benefits from a sound arboriculture include not only cash returns but also improved amenities of shade, shelter and beauty.

Irrigation prospects

The conservation of the vital water catchment areas of the Punjab rivers holds great importance for the irrigation engineers and for many years the Central Board of Irrigation has been clamouring for more effective conservation measures in the high hill catchments which serve the major canals. Now in addition they have an ambitious programme of high dams. Each of these dams will block the passage of a river whose load of silt and sand has previously been carried away either to the sea or spread afar by the irrigation water. With the complete stoppage of the stream flow its entire load of silt, sand, pebbles and boulders will be dumped on the bottom in the reservoir behind the dam thus filling up valuable storage space with debris instead of water.

Construction of dams

The load of silt and sand carried by the Beas and the Sutlej is particularly bad in times of heavy flood when the snow melting in the high hills combines with torrential downpours causing heavy erosion damage in the foothills. The Bhakra dam on the Sutlej is already in hand and plans for others on the Beas, Ravi and Giri are being prepared. Every effort must, therefore, be made to ensure that the catchment areas above the selected dam sites are in the best possible condition to reduce siltation. This entails much stricter control of grazing than has ever before been attempted, and cancellation or commutation of grazing rights which are found to be harmful. In the case of Kangra particularly a radical reduction in the number of grazing animals is essential, for it has recently been computed that Kangra now holds 1,000,000 livestock although it is capable of feeding only 200,000 properly with the existing facilities for grazing and grass cutting.

Reclamation of thur lands

Next we have the reclamation of *thur* land and water-logged areas. Neither of these are strictly speaking forestry problems; but much of the land which has gone out of cultivation owing to its heavy salt content or owing to waterlogging is in such a bad condition that it is unlikely ever to be rendered fit for cultivation and can at best be expected to produce a tree crop. Trees in many cases will be a means to an end because their very presence assists to re-establish a productive soil and a better drainage. Where irrigation water is available *thur* salt can be cancelled by growing two or three crops of rice, then putting it under trees for a number of years. Similarly in waterlogged land when drains are first opened tree crops may give a better return than any field crop would in the first few years during which drainage is being introduced.

Wind-breaks and shelter-belts

The last but by no means the least important of the Forest Department's proposed activities is the establishment of wind-breaks and shelter-belts to control the movement of wind-blown sand. Many in India are familiar with the tragic tale of the American 'Dust Bowl' where ill-considered ploughing of natural grasslands and failure to provide shelter-belts in a hot and wind-swept country somewhat similar to our southern Punjab, led to extremes of poverty and suffering which has been ameliorated to some extent by the Federal Government's action in planting a vast number of narrow shelter-belts along field borders, roads, railways, and waste lands to form a defence against the prevailing wind. Unless some similar project is worked out for our desert-fringe areas of Gurgaon, Hissar, Sirsa, Ferozepur, Fazilka, Multan and the vast tract of the Thal desert between the Indus and the Jhelum, increasing poverty and aridity in this already treeless tract is unavoidable. Just how far such a project can actually make land available for ex-servicemen is not yet clear, but the first step is to demonstrate to the residents of these areas the value of shelter-belts of trees and in areas where trees cannot be grown, wind-breaks of cane grass can be used to stop the shifting sand.

Contour bunding

The Bombay Presidency has already demonstrated that her scarcity areas can be tremendously improved by means of contour bunding. In Bijapur dry zone area; where rainfall is slightly higher than at Hissar, farming conditions have been vastly improved and some four lacs of acres have been contour bunded within the last two years. The Forest Department proposes to carry out similar work along the Punjab desert-fringe districts with the co-operation of the Agriculture Department and to work out details of land use and crop production in the reclaimed areas. The fact that Bombay was a Section 93 province when the work was undertaken implies a certain amount of compulsion having been used, but in actual practice almost all the cultivators have welcomed the scheme and there is a long list of villages which have asked for this work to be undertaken. The work in the Punjab would of course be based on the voluntary principle which has been so successfully exploited by the Co-operative Department in its dealings with the cultivator, but unfortunately many of the districts requiring reclamation are those in which the co-operative movement has not made great progress.

Anticipated expansion

The five years' programme outlined above is estimated to cost Rs. 2 crores starting with 19 lakhs in the first year working upto 66 lakhs in the fifth year. This expenditure covers not the purchase of machinery and the employment of very large number of men for labour, but also entails expansion of our technically trained staff. These developments have already been anticipated to some extent and the training colleges for Forest Officers and Rangers at Dehra Dun and for Foresters at Ghora Gali are being expanded. It is hoped that many of those who will be selected for training will be ex-servicemen but apart from these higher grades of technically trained officials there will also be a big demand for ex-soldiers in posts of *daroghas*, forest guards and co-operative society guards, provided these young men are prepared to take their coats off and work.

The objective

The ultimate object of the Forest Department's scheme is to stop soil erosion wherever

it is serious and conserve rainfall throughout the Punjab so as to make more water available for irrigation, agriculture, livestock and for the villagers themselves. In view of the enormous amount of damage and deterioration which is now going on in most parts of the province except the irrigation colonies, this objective can only be attained by effecting radical changes in the present uses of land, both waste land and fields. If we are to fit the returned soldier harmoniously back into his village we must harness his comradeship, initiative and discipline to make a success of this carefully planned scheme of national reconstruction in which afforestation and soil erosion control are important items.

Indian Farming, Vol. VI, No. 12, December, 1945.

FARM FORESTRY

George R. Phillips

(Associate land-use co-ordinator, Office of the Secretary, U.S. Dept. of Agriculture, Washington, D.C.)

This paper, presented at a meeting of the Washington Section, Society of American Foresters, on January 23, 1945, stresses the importance of better management of the country's 185 million acres of farm woodland. From the standpoint of each of the 3½ million farmers involved, such management is intimately connected with proper management of his entire farm—the production plant from which he earns his living. Full use needs to be made of public and private educational service and facilities to help instill into the cultural pattern of our farmers an inherent desire to operate their farms so that their woodlands are properly managed.

Farm forestry has to do with the proper management of the farm woodland as a part of the farm production plant.

To be a farm woodland, according to the U. S. Agricultural Census, a patch of woods must be part of a tract of land which contains at least 3 acres, or which produced $250 or more of agricultural products last year, and which is directly farmed by one person. This definition leads to some rather confusing situations. For instance, a country merchant may own a tract of land near the village where he carries on his business. He may have a tenant on the farm. The tenant may handle the crop and pasture land, but the merchant may himself handle the woodland so that he can personally profit to the maximum extent from it. Nevertheless, the woodlands is classed by the Census as a farm woodland because it is a part of the farm and the arrangement for handling the woods is not readily evident.

On the other hand, the merchant may also own another tract of land, all of which is forested, situated either near to or at considerable distance from his farm. He may handle it just as he does his farm woodland. However it is not regarded as a farmwoodland but rather as "non-farm" or "privately owned" forest land because it is not a part of a farm. This is indicative of the close relationship between the farm and the non-farm segments of the so-called "private forestry" field, and of the complications that are encountered in attempting to deal with specific portions of it from a strictly forestry standpoint.

Importance of Farm Woodlands

A brief look at the over-all private forest land ownership situation further emphasizes this relationship. About 70 per cent. of the privately owned commercially productive forest land in this country is held by over 4,000,000 owners, none of whom own more than 5,000 acres.

The big job ahead in private forestry lies here. It involves not only the landowners and operators—farmers and non-farmers—but thousands of small sawmill men and operators of small wood-using industries as well. It also involves the pulp mills and their buying policies, organizations, and personnel.

Farm forestry is an important part of this field. Some 3½ million farmers own 185 million acres of farm woodland—about 30 per cent. of all the forested land in the country. Nearly 139 million acres of it are classed as commercial, and over 46 million acres as non-commercial.

In general, the commercial farm woodlands are situated on better soils than are the woodlands of similar classification in non-farm and public ownership, so that their potential productive capacity as a whole is

relatively high. Too, the farm woodlands are located closer to markets.

Over 92 per cent. of all farm woodlands are east of the Great Plains, and about 50 per cent. of them are in the South.

The important contribution that farm woodlands have made to the development of our farms and of the nation has been at the expense of a heavy drain upon them. This wooded acreage furnishes nearly one-fourth of the sawlog supply in the United States, about one-third of the pulpwood, and large volumes of fuelwood, fence posts, and other products.

Condition of Farm Woodlands

Large numbers of farm woodlands are in a depleted and run-down condition. At one time or another they have been high-graded and over-cut. Many of them have long been overgrazed, with especially damaging effect in the hardwood types. Extensive acreages, particularly in the South, are frequently burned over. Average annual growth per acre is variously estimated at from one-fourth to one-half the potential, and this without reference to the relatively low-quality species on which considerable of it is produced.

There is a denuded area on farms estimated at over 30 million acres, generally conceded as best suited for tree production, which needs to be planted.

There are scattered about the country a sufficient number of contrasting exceptions to the general picture of deterioration and abuse to illustrate well the productive possibilities of farm woodlands. Some individual farmers with a particular interest in trees have handled their woods very well. Even communities of farmers, frequently those with common ethnic back-grounds or religious beliefs, whose cultural pattern includes careful husbanding of their forest resources, have applied their traditional methods with results that contrast strikingly with the general picture. About 30 per cent. of the commercial farm woodlands are being well managed, although 75 per cent. of these are deficient to some degree in their basic growing stock.

The feeling, widely held since early pioneer days, that trees are an obstacle to settlement and to farming has proved an effective deterrent to recognition of the farm woodland as a continuous income producer and to its proper management. This situation is gradually changing, but farmers as a whole have not, on their own initiative, taken steps to improve the methods of handling their woodlands. It appears to be even more difficult to get conservation practices applied in the management of farm woodlands than of cropped and pastured lands. If the public interest is to be protected, the forest resource conserved, and opportunity retained for farmers to obtain a continuous return from their woodlands, information on the benefits to be obtained from forestry and forestry assistance must be brought to the owners of farm woodlands.

Assistance to Woodland Owners

This was recognized in the authorization of the old Department of Agriculture Division of Forestry. In response to requests, foresters from Gifford Pinchot's "bull-pen" were sent out to help owners draw up plans for management of their woodlands. Although major emphasis was placed upon assistance to owners of larger tracts, some help was furnished to farmers. Among the states, long ago Maryland first made the service of foresters available to farmers on a consulting basis for a reasonable fee. Others have since followed suit. Michigan and New York were among the leaders to include forestry in their extension teaching.

In accord with the rather widely held feeling in the early part of the century that tree planting and fire protection constituted the major steps in obtaining application of forestry on a broad scale, a number of states established forest tree nurseries and sold forest planting stock to farmers at nominal prices. When the Clarke-McNary Law was passed in 1924, a means was provided for the Department of Agriculture to co-operate, through the Forest Service, with the states in this work, which was enhanced by the Norris Doxey Act of 1936. This co-operative work expanded so that in 1941 over 97 million trees were distributed by the 42 co-operating states and 2 territories. Because of the war, distribution has been materially reduced (74 million in 1942, 46 million in 1943), but evidence is already developing of a greatly

increased post-war demand. To date, more than 750 million trees have been co-operatively distributed.

The Clarke-McNary and Norris-Doxey Acts also provided for co-operative work by the Department of Agriculture and the states in educational work in the farm forestry field. Facilities of the Extension Service are utilized to bring to farmers, through the country-wide county agent system, information on the desirability, value, and methods of planting trees and of applying good forestry practices in the management of farm woodlands. Demonstrations are held to show groups of farmers how these practices are applied. Nearly 2,200 counties reported farm forestry activities last year, including reforestation, erosion control and protective plantings, cultural and harvest cuttings, timber estimating and appraisal, and production of maple sirup products and naval stores. Members of 4-H Club are trained in various conservation practices and conduct forestry projects. The department is now co-operating in this work with 44 states and 2 territories. Some 50 extension foresters are employed to work with the county agents in the states.

Several states, as a means of inducing farm owners to retain and properly manage portions of their farms as woodlands, enacted tax reduction or tax exemption laws. While in general farmers have not taken advantage of these inducements to the extent hoped for, this approach has been in large part responsible for greatly improving the condition of some 100,000 acres of farm woodlands in Indiana and lesser acreages in other states.

The importance of forest cover as a means of preventing erosion was recognized at the outset in public efforts at soil conservation. Millions of trees were planted on farms by the C.C.C. under the direction of state and federal agencies.

The Forest Service planted over 222 million trees in 18,600 miles of shelterbelts and in other protective plantings on 33,200 farms under co-operative arrangements with farmers in the prairie-plains region. Over 40 per cent. of the plantings are now in soil conservation districts, through which the Soil Conservation Service is able to provide some follow-up assistance to those farmers whose plantings still require cultivation or replanting of fail places. The project, always popularly known as the "Shelterbelt Project" despite its various official names, was an unqualified practical and technical success as far as it went. The local beneficial effects of the plantings to prevent soil blowing to protect crops from hot dry winds, and to provide a haven for song and game birds, are widely acclaimed by farmers whose lands are protected.

The Soil Conservation Service assisted farmers in the planting of an additional 53 million trees, in the same general area, in some 4,400 miles of shelterbelts and other protective plantings on an additional 36,200 farms.

Conservation Planning on Farms

The Soil Conservation Service gives the same consideration to farm woodlands as to crop and pasture lands in helping farmers develop conservation plans. In assisting 1,055 soil conservation districts, within which live half of all the farmers in the country to provide technical assistance to farmers in the complete utilization and proper management of their productive assets, full consideration is given to the importance of trees and other woody plants, not only as cover to prevent erosion but as a desirable habitat for game and non-game birds and animals and as a crop to produce income and products for farm use. In helping farmers to budget the time they devote to various kinds of farm work, consideration is given to the returns they may expect from their farm woodlands as compared to the returns from other parts of their farms. It is necessary to balance the amount of time devoted to woods work with that required for equally effective operation of other parts of the farm in order that the farmer may obtain the greatest possible return from the plant that provides him a living. In addition to the time that can logically be devoted to work in the woods, an effort is made to get farmers to devote otherwise idle time to improvement of growing conditions in their farm woodlands and to the production of forest products from these woodlands.

As a result of conservation planning of farms and farm operations with individual farmers, the stage is well set for those furnished this assistance to handle their woods properly along with other parts of their farms. The

information and advice given farmers by soil conservationists—men with varied basic agricultural or forestry schooling and special training in conservation planning—at the time plans are made is frequently sufficient to guide them in minor cutting operations. Because of the relatively large number of farmers furnished this assistance, it is an important factor in getting forestry applied in handling farm woodlands.

Experience indicates, however, that farmers still need more detailed assistance when cutting operations of a relatively extensive nature are under consideration. This is true even in the case of many farmers who have been sold on the advantages of applying good forestry practices and who have had the benefit of conservation planning assistance, and still more so with farmers who have not had these advantages.

Demonstration and Marketing Projects

This need was recognized in the Norris-Doxey Act. In an attempt to accomplish some readily visible results and to gain additional knowledge in this field, 52 intensive demonstration projects have been set up by the Department of Agriculture and the states in about a third of the locations where they felt such projects could be profitably established. It is hoped that through the years these groups of farm woodlands will be so handled that they will stand out as demonstrations of what can be done by good forest practices. They should also form nuclei for the establishment of forest co-operatives and of stable wood-using industries. Detailed records are being kept on a portion of the woodlands in each community group so that facts about investment of labour and cash, about income, about kinds and amounts of products cut, used, and sold, and about changed conditions of stocking and growth will be available for study along with the visual evidence of good forest management. Much valuable information has already been developed, but, since it takes time to build up performance records, the greatest value of these demonstrations will probably come after a couple of decades or longer.

With the advent of the war and the increased demand for forest products, widespread effort was made to obtain many of these products from farm woodlands. Extensive cutting, for the most part of a very destructive nature, took place. The Department of Agriculture and the states saw this both as a challenge and as an opportunity so that when funds were provided under the Norris-Doxey authorization a series of co-operative farm woodland marketing projects, now numbering 89 in 28 states and serving 371 timbered counties, was established. These projects, locally administered by state foresters or extension services, where they have the means to co-operate, have furnished a technical forestry service to considerable numbers of farmers in connection with the cutting, marketing, and utilization of their timber. The projects have been administered on the principle that needed products could be gotten out in a manner that would contribute to improved conditions in the woods.

Farmers have been brought into contact with buyers of wood products and have been given help and guidance in securing fair prices for their products. Buyers are encouraged to see that in the long run it is to their advantage for farmers to receive such prices and for farm woodlands to be left in productive shape to assure the continuous log supply required by dependent mills.

During the fiscal year 1944 a total of 8,284 farmers were given marketing and management assistance on 661,000 acres. Of these, 4,364 made harvest and improvement cuttings on 178,000 acres. Total wood products cut from farm woodlands with the assistance of farm foresters under these projects amounted to 300 million board feet. In addition, 6,105 barrels of gum naval stores and 12,573 gallons of maple sirup were produced.

The value of this work is illustrated in the southern region of the Forest Service, where the federal government spent $53,558 and the states $56,774 during the last fiscal year. The farmers who were given assistance received $1,739,385 for their wood products. This is estimated to be at least $435,000 more than they would have received without the assistance. Because this service was available, some owners consented to market certain high-value trees for special uses that would not otherwise have been made available to

meet war needs. The material was produced under good cutting practices.

To provide a marketing service in all of the 2,000-odd forested counties, comparable to that now available in the counties served would require about $3,500,000 annually. It might be shared 50-50 by the federal government and the states, as under the present program, and would provide many employment opportunities for foresters. Certainly it could be an important factor in better management of farm woodlands on a broad front.

Problems and Opportunities

Various specific forestry problems, of principal concern to farmers, have been encountered by foresters engaged in farm forestry work. The Forest Service is co-operating with several state experiment stations in research on such matters as the relative desirability of growing forest crops or forage for livestock on certain sites, the use of wood in various forms for fuel, and the availability of markets for various kinds of farm woods products.

Devotion of the appropriate parts of farms to production of forest crops is a wise use of land, and the application of sound forest practices in the management of farm woodlands is a fundamental part of good conservation farming. Increased farm income, increased quantities of farm products, minimum erosion damage, better utilization of farm labor, and a contribution to an economy of plenty all result from an adherence to such policies.

Obtaining widespread understanding and application by farmers of the fundamentals of good forest practice is a big job. The efforts of the Department of Agriculture in this direction are furthered by developing a place for farm forestry in its various programs affecting farms and farm people, with assistance to other bureaus provided by the Forest Service—the Department's forestry subject-matter agency.

The Farm Credit Administration is encouraging the federal land banks to give increasing recognition to farm woodlands as a collateral asset and source of continuous income. Several of these banks now make loans to individuals on strictly forest properties and on farm units that include timbered lands where the owners follow sound forestry practices. Several banks employ foresters or woodsmen to look out for the interests of their borrowers and of the banks in connection with sales of forest products from borrowers' farms.

Payments are made for carrying out soil-building practices under the Agricultural Conservation Program, including a number that directly encourage the application of good forestry practices to conserve and improve the soil. The naval stores program has been an important factor in obtaining widespread application of improved practices by gun farmers.

The Agricultural Research Administration works with department and state agencies in combating tree diseases and insect infestations. Its advice has an important bearing upon recommended cutting practices in various forest types.

The Farm Security Administration, until its activities were curtailed at the start of the war, employed 8 foresters, through an arrangement with the Forest Service in several of its regions where forests are important, to train and assist its field personnel so they could help clients to make best use of farm woodlands as continuous income producers.

The forest-products industries have made a commendable effort to stimulate an interest in forestry, as illustrated by the establishment of the "tree farms" movement, the educational efforts of the Southern Pulpwood Conservation Association and the provision by certain mill operators of assistance in forestry management to owners of farm woodlands in return for the opportunity to buy timber that is grown.

Steps to Further Progress

With full recognition of what has been done to date in getting farmers to understand and accept forestry as a part of farming, the job is still largely ahead. A great deal of progress might well be made by an even more widespread use of the personnel in existing governmental organizations. To use a military term that indicates the simultaneous forward movement of separate but related units (or in this case, efforts) toward an established objective, the job might be divided into several echelons.

The first would be to train a larger number of federal and state employees whose principal work with farmers is in some other field than forestry, and a greater number of farm leaders, to recognize the advantages of good management practices in existing farm woodlands, and to understand how to apply elementary forestry practices in the woods. This might be accomplished through farm forestry short courses, through farm forestry courses for students at agricultural colleges, through "in-service" training courses to present personnel, and through extension teaching.

The second echelon would provide widespread contact of these forestry-indoctrinated people with farmers, to get simple fundamental forestry practices applied in the management of farm woodlands on a broad front. Among the many avenues of approach to this objective are assistance to farmers through soil conservation districts; to clients of the Farm Security Administration; to formers participating in the Agricultural Conservation Program; to borrowers from subsidiary lending agencies under the Farm Credit Administration; and to farmers generally by extension services and state forestry departments through their field organizations.

The third echelon involves recognition that many farmers, once they grasp the fundamentals of good forestry practice and taste their benefits, will accept, in fact will probably demand, a higher standard of woodland management than they can be initially taught. The first step in this direction is to provide technical forestry service on a "meet-the-immediate-need" basis in an effort to get more good forestry practices applied in woodlands where cutting is taking place during the war. Service in the marketing of farm woodland products, such as is now being co-operatively provided by the Forest Service and the states in helping farmers obtain a fair price for forest products sold and in properly harvesting timber they sell, is representative of what is needed. This can be a part of the groundwork for the later effort on a large scale to obtain application of intensive practices in the management of farm woodlands. This kind of service should be expanded and improved with experience to meet the increasing requests from more responsive farmers for greater technical help in the years ahead when fundamental woodland management practices are in general use and large numbers of farmers are ready to apply more intensive practices.

We must depend primarily upon the federal and state forestry services and experiment stations as the subject-matter and research agencies to develop the additional information that will be required and to sift it to obtain that of most practical application. They need to be energetically at work.

The Job Ahead

Out of the various public efforts to assist farmers in cashing in on the productive capacities of their farm woodlands, there is already gradually developing a recognition on the part of farmers that it is a paying business for them to invest something in obtaining advice and assistance from foresters in the management of their woodland crops and sale of their forest products. In scattered instances, co-operatives have developed which have employed foresters to assist members in production and marketing of forest products. This is a desirable trend to encourage but it appears to be shaping up too slowly to depend upon as a principal means of getting the job done.

Too, there may well develop opportunities for foresters to establish themselves on a consulting basis to furnish forestry services to farmers. In this regard, it seems fair to assume that such foresters would receive the support and encouragement of public agencies that are now the principal source of such assistance.

These are some of the highlights in the field of farm forestry.

Where the educational and service program of the Department of Agriculture and of the states have reached farmers taking advantage of the recent high prices and good market to sell timber, in general the cuttings have improved the condition of their woods because mature trees and low-quality species have been cut and a good growing stock of the better species has been left.

Where farmers failed to obtain such assistance, in general their woods have been

further slashed. The wide extent to which this has occurred has materially set back progress toward obtaining optimum production from farm woodlands as a whole and has made more difficult the job ahead of getting forestry applied in their management.

As foresters, we owe it to our profession and to our country to see that every facility and approach, by both private and public agencies, is utilized to accomplish the tremendous educational and service job of instilling into the cultural pattern of our farmers an inherent desire to so operate their farms that their farm woodlands are properely managed.

—*Journal of Forestry*, July 1945.

VOLUME 72 NUMBER 9

INDIAN FORESTER

SEPTEMBER, 1946

AIR SURVEY AND SOIL EROSION

FOREWORD

By A. P. F. Hamilton, M.C., O.B.E., I.F.S.

(*Inspector General of Forests*)

We are very greatly indebted to Mr. R. C. Kemp, Managing Director of the Indian Air Survey Co., Ltd., Dum Dum, for permission to use the excellent air photographs which appear in this note. These photographs were not taken for publicity or instructional purposes, but to determine, amongst other things, whether air photography could assist in assessing the intensity and extent of erosion: it is not, therefore, claimed that they are typical of the localities they deal with, not that the survey has been exhaustive, since for the purpose for which the air photography was undertaken, it was not necessary to go as far afield as some of the worst and most extensive erosion tracts, such as the Punjab, Rajputana and the Central India States.

These photographs do, however, give a very faithful picture of what erosion is and what damage it can do. Those who have kept their eyes open while travelling throughout the country by rail, road or air will be in a better position to appreciate the value and meaning of these aerial records than those who have not; and it would be strange indeed if those who care to study these photographs, even cursorily, are not moved to ask what are the causes of erosion and what can be done to prevent and cure it.

Nature abhors erosion as much as She does a vacuum. The gradual degradation of mountains is a natural process constantly at work throughout geological ages, but erosion is a man-made evil. The chief agent employed by Nature to preserve the stability of the soil is vegetation whether trees, herbs or grass, the role of which is to prevent excessive removal of the soil by rain water or by wind. Once this protection has gone the action of rain water, moving over the soil, carries it away into the streams and rivers and eventually nothing remains but rock and stones. Winds also may cause serious erosion, particularly in light or sandy soils. A single rain storm may remove a depth of soil which it has taken Nature a thousand years to build up from the parent rock.

In certain parts of the world erosion has been manifest in the form of sudden and widespread calamities, for example, the wind erosion which followed the conversion of the pasture lands of America's Middle West to arable land. The plough destroyed the grass sod which, with its mat of roots, had bound the light powdery soil for centuries; thus exposed, the soil became the plaything of the winds, and millions of acres of land went out of cultivation. From China we frequently hear of the terrible floods caused by the Yellow and other rivers, which originate in the mountains to the west which have been entirely denuded of the vegetation which, if it were present, would have mitigated, if not prevented, these floods.

Disastrous floods there have been in India, too, and it would be foolish to minimise the necessity for preventing them, but they do not, in this country, constitute the most serious form of erosion. Climatic and soil conditions in this country are, on the whole, such that erosion proceeds slowly and insidiously and is therefore all the more dangerous, as it fails to attract the attention either of the public or of governments. Many millions of acres of cultivation in this country lie on sloping ground; it can be said without fear of contradiction

that some degree of erosion is taking place on every *sloping* field, however gentle the slope may be. This erosion is removing the valuable top-soil and the manure and so reduces the fertility of the field. When erosion is uniform over wide surfaces it is called "sheet" erosion; "gully" erosion is the lengthening and deepening of declivities caused by the concentration of run-off on uneven ground; the softer and deeper the soil, the more rapid and serious is their growth. As they cut deeper they increase the rate of drainage and so accelerate the processes of erosion and desiccation of the soil. Gully erosion may attract more attention, but there are countless millions of small fields throughout the length and breadth of India, the fertility of which is reduced to a consistently low level because steps have not been taken to retain the top-soil and manure by adopting the simple measures necessary to control the movement of water on them.

Broadly speaking the fundamental cause of erosion is the misuse of land by man. Forest is burnt or otherwise cleared to provide more grazing or cultivation; the grazing reduces the ground vegetation and erosion begins; the cultivation is of a temporary nature, the stability of the slope is destroyed and erosion begins—in both cases the land is ultimately lost to the use of man. Side by side with this, forests and grazing lands are destroyed by uncontrolled fellings and by the grazing of excessive cattle (and it must be remembered that there are enormous tracts of forests and waste land which are not under management by local administrations). In this way the villagers ultimately destroy the source of their firewood and timber supply and their grazing. Increase in population has, without doubt, contributed to the process of land destruction through erosion. In the early days of his settlement on the land, the villager cultivated the good land near the village; it was well manured and cared for, and permanent: it produced all he and his family wanted: there was sufficient forest and waste for firewood and grass. Families increased in size and it became necessary to break land further afield; this meant clearing forest or taking up land steeper or otherwise less suitable for cultivation. Less care was lavished on the new land, as is always the case if it is unlikely to be permanent. Owing to the failure to hold the rainfall by terracing or bunding the soil either lost its fertility, or disappeared altogether through erosion. Then more land had to be broken; and it has gone on, cultivation being extended in a widening circle, multiplying the *foci* of erosion; and in spite of greater effort the cultivator now gets less return from his holding, while much, if not all, of the source of his firewood and grass has disappeared. The poverty of the cultivators and the miserable condition of the cattle is due to this cause, and to no other, in many parts of the country.

These are days when much is being said about growing more food and raising standards of living, and ambitious schemes for irrigation by canal and tube-well and for the use of tractors are being discussed. But over vast tracts of the country, the poverty stricken millions are struggling to exist on their eroding fields and wasted lands, where neither irrigation, not tube-wells nor tractors can give them any help; proper land management alone can save them.

Prevention is better than cure: forests are still being wantonly destroyed, cattle are being grazed indiscriminately in increasing numbers and slopes are being torn into worthless fields. The village waste lands and forests must be preserved and managed for the future use of the cultivators by village *panchayats* or societies, or by government on behalf of the villagers, grazing grounds must be improved by a system of rotational closures and sloping land, if it must be cultivated and is suitable for the purpose, must be protected from erosion by terracing or contour bunding. The secret of success in soil conservation work is to reduce the flow of water over the land to a minimum, to make it sink into the ground where it falls so that a natural reservoir is formed in the subsoil, and to provide controlled drainage for excess storm water: if these measures are taken, neither sheet nor gully erosion will appear and permanent fertile fields will be the result: terraced paddy fields are a fine example of this. And so it is with the cure: the point when nothing can be done to reclaim eroded land is reached only when naked rock and stones are left. Gullied land may be too deep to reclaim to cultivation but it can be made to grow trees, bushes and grass which are useful to the cultivator and prevent the gully extending further: gully heads cutting into cultivation can be stopped entirely by checking the flow of water into them from the surrounding fields by levelling and embanking the fields and by fixing small check-dams in

the gullies, though this latter is less important. Once the flow of water from the fields is controlled, the beds of large gullies can often be reclaimed for cultivation by raising silt beds above dams. Sheet erosion is automatically stopped when fields are levelled or the flow of water on them controlled by contour bunds. Finally, any wasted land can be made productive by afforestation or re-grassing.

The remedies are well known but the application is often difficult. Soil conservation measures, to succeed, must be carried out according to a concerted plan—the co-operative efforts of the cultivators must be forthcoming and it is not always easy to secure this. Again, there may be a conflict of interests between landlord and tenant, as in the case of closures: in many cases cultivators simply do not realise the imperceptible effect of sheet erosion on their fields; in others, they have long since accepted what they consider the inevitability of gully erosion.

In America soil erosion is considered a national menace; it is a much greater menace in India where the standards of living and of nutrition are so low. A national menace must be fought by a national effort; the greatest fertiliser of the soil, water, must not be allowed to run waste and to take with it the top-soil which is the wealth of the nation.

Schemes for the proper and most effective utilisation of the land are required in order that a well balanced village economy may be established which will provide the cultivator with the timber, fuel, grass and food which he cannot do without; this is the real meaning of soil conservation, the proper use of the land.

AN INVESTIGATION INTO THE POSSIBILITY OF USING AIR PHOTOGRAPHY TO ASSIST IN DEALING WITH SOIL EROSION

BY THE AIR SURVEY COMPANY LIMITED, DUM DUM.

The questions which were put forward for solution were :—

(1) Whether the air photographs would clearly show gullying?

(2) Whether sheet erosion in its varying forms and stages can be detected and classified from an examination of air photographs?

(3) Whether the areas of the affected parts, and of the gullies can be determined by measurements from the photographs, or with the aid of the photographs by air survey methods?

(4) Whether air survey can in ways other than mentioned above, assist towards finding a means of dealing successfully with erosion?

These questions were put to the Indian Air Survey and Transport Ltd., through the Director of Civil Aviation in Burma, and Mr. R. C. Kemp, Managing Director of the Company, visited the Federated Shan States on the 2nd September, 1940, to assist in the investigation.

Mr. Kemp was met at Kalaw by Mr. T. D. Griffiths, and Mr. T. S. Thompson, of the Burma forest service. Mr. Griffiths is in charge of the work now being carried out in the Shan States, and the investigation of the whole problem; while Mr. Thompson is seconded for special duties in connection with a survey of a selected area, which is subject to erosion.

Mr. Griffiths explained the situation in detail, and the work which they are carrying out, including the survey by Mr. Thompson, and the various experiments over part of the affected area.

The road from Kalaw to Taunggyi, (where the undersigned spent the second night) runs through the heart of the affected area, so that it was possible to observe erosion in its various stages, and the effect of erosion.

The country is undulating, but while there is no very great variation in altitude, some of the slopes are comparatively steep. Originally almost the whole of the country must have been forested, but this has been cleared and given place to cultivation of various kinds.

In recent years it was explained, the type of cultivation has changed, probably as a result of a greater demand for ready money. One of the effects of this appears to be the cultivation of potatoes, which seems to have accelerated sheet erosion, there being little or nothing on the ground to hold the surface soil during heavy rains, nor are the potatoes grown in lines as in Europe, which, had they been arranged in parallel with the contours, might have been an adequate prevention against erosion. As it is, the potatoes are planted nearly as one would a plantation of trees, each having to itself a small hummock of soil mixed with burnt vegetation. This it will be seen can be viewed in parallel lines, from whichever way one cares to look, so that looking down the hill one sees lines of hummocks between which the water can escape from the hillside in regular torrents, washing a great deal of soil with it.

The above is only one of the many ways in which the cultivator is not helping towards the prevention of erosion. Uncontrolled grazing is another, and altogether it would appear that it will be necessary to control the whole of the affected areas, not only as regards cultivation and grazing, but in many other ways, including the domestic existence of the cultivators, if the countryside is to be saved.

This is rather apart from the actual investigation in hand, but these points were explained to Mr. Kemp by Mr. Griffiths, in order to assist him in advising whether air photography would fulfil the requirements as specified previously.

The company has been operating in Burma for several years, and as it happens a great deal of their flying has been over districts in Upper Burma, notably Meiktila and Myingyan, in which erosion has reached almost its final stage, leaving great tracts of the country almost destitute.

Sample photographs were taken over parts of these districts, and had prior to this investigation, been submitted for examination by Mr. Griffiths. They were not, however, quite suitable, owing to the vast difference in the state of the countries in question. They show erosion to an extent where the whole country-side is completely feathered by gullies, and in most cases the watershed between, has been completely stripped of any cultivable soil, and as often as not, of any flat or reasonably sloping surface, which might be suitable for cultivation if not already ruined by sheet erosion.

At the time of the investigation, Mr. Kemp was unable to say whether the company would have a party working in Burma in the following season. For this reason, a search has been made through the Company's stocks of photographs and negatives in Dum Dum, with a view to finding further samples which might lead to a decision as to whether air photography can assist in the case.

During this search several reports on the allied subject of deforestation were examined. References in respect of areas in Western Bengal, Bihar, Orissa, and Chota Nagpur were noted (*see Appendix*, *page* 422) and this resulted in a search for photographs which might fall in these areas, a few samples of which are now attached (*vide plates 31—44*).

In Bihar and Orissa, and also in parts of western Bengal, it would appear that the greatest concern has been felt by the reckless cutting of forests, resulting in the denudation of the surface soil. The reports do not, however, touch much on the problem in the next stage, other than in the form of forecasts.

In the neighbourhood of Ranchi, the problem is somewhat similar to that of the Federated Shan States, in that the ground is undulating and gullying has eaten into a very large percentage of the cultivation, (*see photographs* B7-4 *and* 5, *plate* 31). In these parts, however, whether by long experience or recent tuition one cannot say, the cultivator appears to be working against his enemy with some success. You will observe in photographs B8-1, and B8-5 (*plate* 34), that the fields are narrow and generally run across the slopes. In B8-5, it would appear that the river has gradually worked across the basin, and the numerous cultivators have evidently extended their property as a result of this. But near the river, where the level falls away, the fields are along the contour.

In photograph B2-3 (*plate* 35, *Fig.*9), also in the Ranchi area, there is a probable case of sheet erosion in the patch of uncultivated

country adjoining the forest. It would appear that the forest is thinned out to a dangerous degree towards the edges, and in all probability sheet erosion takes place before the forest is entirely cleared. It will be noticed, however, on a careful examination of the photograph, that there are faintly showing a number of parallel lines running across the slopes. Whether this is an attempt by the local inhabitants to prevent erosion by digging dykes and *bunds*, or whether it is something to do with reforestation, it is impossible to say without local knowledge.

Since this investigation started, another case of a parallel nature has been put to the company. A recently appointed committee, is now looking into the various problems relating to the ever increasing flooding of the territory adjoining the lower reaches of the Bramaputra and the Ganges. It is thought by some members of the committee, that the source of their trouble is *jhuming* (shifting cultivation), known in Burma as *taungya* burning. Erosion accompanied by gullying is taking place in many parts as a result of this deforestation, and indeed on almost all sides of the Bramaputra and the Sarma basins, with the result that an immense amount of silt is annually brought down in suspension by this river, and dropped as the stream slows up in the flatter basin to the south. This is notably so in the stretch of the river north of the confluence of the Ganges and the Bramaputra. It is probable that it is a case similar to that on the Mississippi, which it is understood was greatly aggravated by the disgraceful exploitation of forests before control was introduced.

It is known from observation from the company's aircraft as they have passed over the Khasi Hills, that erosion, as a result of deforestation, has gone to disastrous lengths. There are now vast stretches of barren rock washed completely bare, while there are large areas not so far advanced, but still affected by sheet erosion to the extent that they are now almost useless for cultivation.

Photograph No. 1158/61 (*plate* 37, *Fig.* 13), is not a good example of this, but it shows a part of the neighbouring Garo Hills which is affected in a like manner, but not to such an advanced state. It should be noted that there is an irregular patch of useless country, while most of the remainder of the photograph shows secondary jungle or scrub, which is again being subjected in patches to *jhuming*.

The effect of sheet erosion in slightly undulating country can be seen in photograph RT5-5 (*plate* 35, *Fig.* 10), taken in Bihar in the month of October, at a time when the whole countryside should either be under cultivation, or showing signs of cultivation. It will be noticed that a greater part of the high ground, which shows white on the photo, is devoid of cultivation, and much of it the subject of sheet erosion. It would seem that the alluvium may have to some extent enriched the low ground, for in almost every case there is some sort of cultivation going on, probably paddy in the beds of the *nullahs*. Around the edges, and more especially at the end of the long patch of the light coloured country, will be seen typical examples of gullying, or fingering, as termed in the Federated Shan States. These, however, have not reached the stage of deep ravines.

Photograph RT 1-6 (*plate* 36, *Fig. 11*), shows hills and undulating country sadly deforested. There is a certain amount of scrub still struggling to exist on the hillsides, but it is obvious that the hills have suffered from erosion, while the basins between the hills are generally devoid of cultivation as a result of gullying. In some cases a number of the older gullies appear to have settled down and are growing vegetation, possibly cultivation.

Photographs taken in 1928-29, for the revision of cadastral maps in the United Provinces, as for example A2/F 5 & 6 (*plate* 39) show that gullying was a very serious problem at that date. The ground is comparatively level with very little elevation above that of the rivers. In spite of this, gullying appears to stretch great distances and have laid to waste wide areas. The same is found in the alluvial basin of the Narabada river. (*Photographs N*2, 1 *and* 2 *in plate* 40.)

Photographs BB1 10 and 11 (*plate* 41), also BB1 19 and 20 (*plate* 42), show undulating country in Burma subjected to sheet erosion and gullying. It will be noticed that some of the cultivation still carried out near the watershed is protected by *bunds*. There is, however, little or no sign of terracing.

In the Central Provinces, great stretches of country are affected by erosion in a curious form. It has been noticed frequently that the cultivated fields, many of them large, appear to be getting smaller, resulting in large stretches of fallow land, which grow sparse grass, and a little scrub. These are obviously used for

grazing (grounds) and near the towns for driving cattle to and from their grazing grounds. The grazing seems to be controlled to the extent of keeping it from the cultivated land, but not, we imagine, sufficiently controlled to allow any one of these patches to grow sufficient grass to prevent sheet erosion. This country, however, has one rather long hot and very dry season, and we imagine that in addition to erosion by water, the already eroded areas, and possibly also the cultivated areas are subjected to erosion by wind. Print No. U 3/3 (*plate* 43, *Fig.* 24) is not a good example of this, but sufficiently good to illustrate what has been observed. Print No. U 4/3 (*plate* 43, *Fig.* 25) from the same locality, shows sheet erosion and typical gullying. It will, bowever, be noted that scrub is growing in the gullies and probably to some extent tending to stabilize them.

In carrying out the stereoscopic interpretation of these photographs, it has been found that the lack of local knowledge is a handicap, and it is thought that the combination of good photo interpretation with reasonable local knowledge, will overcome all difficulties in this respect. The interpreter must know what to expect in the way of vegetation, soil colour as a result of moisture content, etc., at the time of year the photographs are taken. Furthermore, local knowledge is essential to decide on the best time of year to photograph, although it will obviously not be possible to photograph at certain times of the year, on account of cloud and other adverse weather conditions.*

Mr. Griffiths and Mr. Thompson were in September carrying out an excellent survey which will be of immense value. Mr. Thompson was compiling a map on the scale of 4 inches to one mile, using as a basis for this, the original 1 inch topographical sheets enlarged to 4 inches to one mile. He reported that the 1 inch maps were on the whole remarkably accurate, but of course the detail was lacking once the scale was enlarged to 4 inches to 1 mile.

Mr. Thompson's work mainly consisted of drawing in the extension of gullies and tributaries to gullies, obviously formed since the map was made. In a few cases only, had corrections to be made. The location and the extent of sheet erosion was shown roughly in colour, without any attempt to indicate the actual boundaries between this and land still cultivable.

One got the impression, that while this map is going to be very useful as an illustration to a report covering a general survey of the affected areas, it will not in itself be sufficient without the vast amount of detailed and intimate knowledge acquired by Mr. Griffiths and Mr. Thompson. This knowledge may, we feel, be hard to put in report form, in a manner which will assist a new staff to plan and estimate for a programme of salvage or prevention which would be applicable to all parts of the area, mainly on account of the lack of detailed information on the map.

If the project is to develop in a form which might be described as regional planning, then we believe that more detail must be provided, and we are satisfied that we can safely recommend air photographs for this.

One of the difficulties about using air photographs will be the classification of soil value, and the determination of the stages of sheet erosion. There is no doubt that the difference between cultivated land and uncultivated, can be quickly distinguished by careful stereoscopic examination, but it will be more difficult to determine the difference between land lying fallow as a result of sheet erosion, and land in fallow as a result of rotation only. We believe, however, that local knowledge will help us to overcome this difficulty. It is possible that eroded land at no time recently cultivated, will be indicated by :—

(1) the lack of orderliness,

(2) little or no signs of field boundaries,

(3) standing grass unattractive for grazing,

(4) recently subjected to grass burning,

(5) obvious signs of cattle tracks, etc.

Land lying fallow at the time of photography but which is subject to cultivation at other times of the year, even if covered with grass, will, we believe, indicate its true nature by boundaries, drainage dykes, lay out of paths, the termination of ploughing and/or a crop, etc.

*Readers are also referred to the air photographs which illustrated the acrticle of Dr. A. L. Griffith on the value of "Aerial reconnaissance for forest officers" in the May 1946 issue of the *Indian Forester*. A number of those photographs were of wind and water erosion in the Thar desert of Sind. It is interesting that he also stressed the fact that air reconnaissance is complementary to and not a substitute for ground reconnaissance. —*Hon. Ed.*

Turning again to the points under investigation.

(1) There is not the slightest doubt that air photographs will show clearly the extent of gullying.

(2) There is still a little doubt as to whether sheet eroded parts can be accurately determined to an accuracy of 100 per cent, but we believe that there is no doubt that a reasonably accurate estimate of the extent of erosion can be made.

(3) There is no doubt whatsoever, that areas can be accurately extracted.

(*a*) of sheet erosion as determined by interpretation,

(*b*) of the extent of the gullying; and in addition it will be possible in most cases to contour, or determine the depth of the gullies, if so desired. In a few cases, however, this will not be possible, as the gullies are in certain instances, very narrow, so that the entire detail may be lost in shadow. This, however, we do not think will often be the case, provided the photography was taken towards mid-day.

(4) We are of the opinion that in other ways, air survey can be of great assistance. We visualise a map being made from air photographs, which in conjunction with the information which can be extracted from the photographs, will permit regional planning covering a very fair soil classification; details necessary for salvage and protective works; the determining of boundaries dividing the country into the various grades necessary for this planning; the allocation of grazing land; the settlement of cultivators; land suitable for building without wasting cultivable land for this purpose; contouring, which will determine the alignment of fields and the amount of terracing necessary; the placing of dams for the reclamation of alluvium and the construction of reservoirs and irrigation works; the allocation of parts where afforestation will be possible to determine the area of catchment; and finally the planning of roads and paths, so that these will work in with the alignment of cultivation and drainage.

It is obvious that up to a point, the larger the scale of the photograph, the better the result, *i.e.*, more details will be shown and the easier will be the interpretation. There comes a point, however, when ample and accurate interpretation can be had, so that to go beyond this scale will be a needless expenditure, both as regards the cost of photography and the cost of interpretation, which goes up considerably with the additional number of prints to be set up for stereoscopic examination.

We visualise also the photographs being used in three ways:—

(1) Detailed interpretation to determine many of the points quoted above.

(2) Accurate mapping of the essential detail which becomes necessary owing to the fact, that the extraction of areas cannot with accuracy be carried out solely on the photographs. It will be necessary to map from the photographs to do this, owing to the displacements resulting from the changes in level.

(3) Larger scale mapping in certain isolated localities, especially around the towns, to provide for the development of these localities, and for settlement. In addition under this head, there may be other parts requiring a reasonably large scale map, as for instance, an engineering project such as a reservior.

For the above reasons, we are inclined to recommend a photographic scale of not less than 3 inches to one mile, but not more than 4 inches to one mile, and we think it would be advisable to map at either 6 inches to one mile, or 8 inches to one mile. We do not think that it will be necessary, at least for many years to come, to make a settlement map of any of this country on scales as large as 16 inches to one mile, such as those used for the cadastral or revenue maps in the alluvial plains. Even around the townships, the maximum scale probably required for the present, might be 12 inches to the mile.

Bearing economy in mind, it would seem a pity, since Mr. Thompson has found the 4 inches

to one mile enlargement of the 1 inch to one mile topographical sheets reasonably accurate, to have to undertake the compilation of a map from the air photographs. We might try utilising the photographs without this, but we believe it will ultimately be found advantageous to prepare the map. It would probably be wise not to decide on making a map of the whole area at the start, but the photographs should be taken in a manner that will make mapping possible, lest it become necessary. It may be found from the photographs that in some parts, unlike that which is now under investigation, there may be large tracts of what might be described as 'hopeless', in which event of course, there would be no object in incurring the additional expenditure of mapping such country.

INTERPRETATION OF THE AIR PHOTOGRAPHS

The air photographs printed in this note are not really difficult to interpret; however, the following guide may be useful for those who have no experience of them.

The white roads and paths can be picked out at once, the former often fringed with the black dots of avenue trees.

Villages (which usually lie on the higher ground) are distinguishable by the concentration of communications, clustering of trees, often round the enclosures of fields, as in B7/5 (*Plate* 31, *Fig.* 2), the dark rectangular lines being hedges or walls; in many cases, particularly in B8/5 (*Plate* 34, *Fig.* 8), the buildings themselves are visible; here also there are several full water tanks (dark) and one dry one (white).

All *nallahs* or torrent beds appearing in the photos, *e.g.* bottom right hand corner of B7/5 (*Plate* 31, *Fig.* 2), diagonally across B4/7 (*Plate* 32, *Fig.* 4), bottom of B8/5 (*Plate* 34, *Fig.* 8) and RT5/5 (*Plate* 35, *Fig.* 10) are dry, the white portions representing higher sand deposits, the darker, the course taken by the last flow of water.

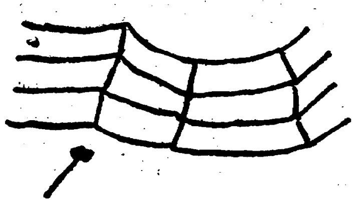
In A2/F5 (*Plate* 39, *Fig.* 16) and N2/2 (*Plate* 40, *Fig.* 19), bottom, are shown bends in rivers.

Main drainage channels, from which the gullies originate, appear as sinuous lines, black, if the bed is damp or of dark coloured soil as in B7/4 and 5 (*Plate* 31), A2/F5 and 6 (*Plate* 39), light, if the bed is dry and sandy, as in N2/1 and 2 (*Plate* 40) and BB1/10 and 11 (*Plate* 41).

The presence of gullying is self-evident; very active gullies, with clean edges and stretching "fingers" can be seen in photographs B4/6 and 7 (*Plate* 32), working out from the two minor torrents; also in A2/F5 and 6 (*Plate* 39), but here the edges are rather obscured by sheet erosion. In N2/1 and 2 (*Plate* 40), the gullies have been largely sealed off by embankments (dark lines) built all round the periphery.

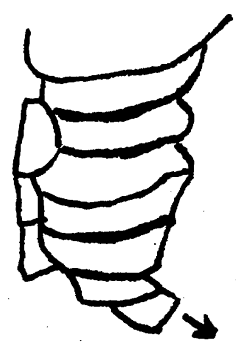
The net work of fields can be readily seen; large square fields generally indicate level, or nearly level, ground. Terraced fields are generally oblong, and usually roughly follow the contour; where fields correctly follow contour alignment they will appear like this:

On broad features.



Down a depression.

Down a spur.



Fields which have proper embankments will show a strong white line, occasionally black, when they throw a shadow, as at the bottom left hand of B4/7 (*Plate* 32, *Fig.* 4) and top left hand corner of B2/3 (*Plate* 35, *Fig.* 9). Weak white lines bounding fields indicate water conservation measures as in A2/F5 and 6 (*Plate* 39) and centre of B2/3/6 (*Plate* 36, *Fig.* 12); in both cases severe sheet erosion has followed, with gullying spreading in the former. In BB1/10 and 11 (*Plate* 41) fields are bounded by hedges. Fallows appear light; fields which are dark may be ploughed, damp, or carry crops.

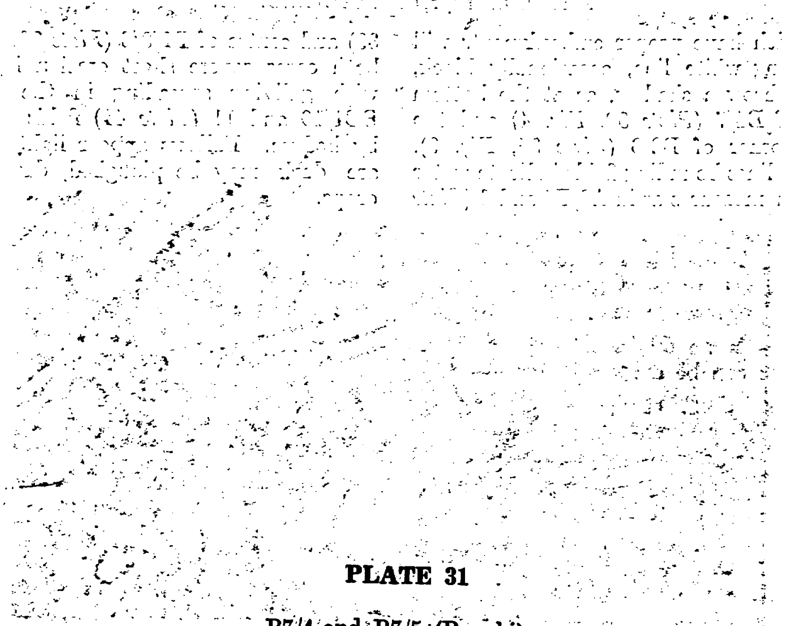


PLATE 31

B7/4 and B7/5 (Ranchi).

Gully erosion in cultivation near RANCHI, Bihar. Sheet erosion is also present, as shown by the light areas fringing the gullies. Sheet erosion, it will be observed is markedly absent wherever the fields alignment follows the contour; terracing has been carried out in a number of places and has stabilised cultivation in some of the older *nallahs* (winding, stairlike strips of darker terraced cultivation).

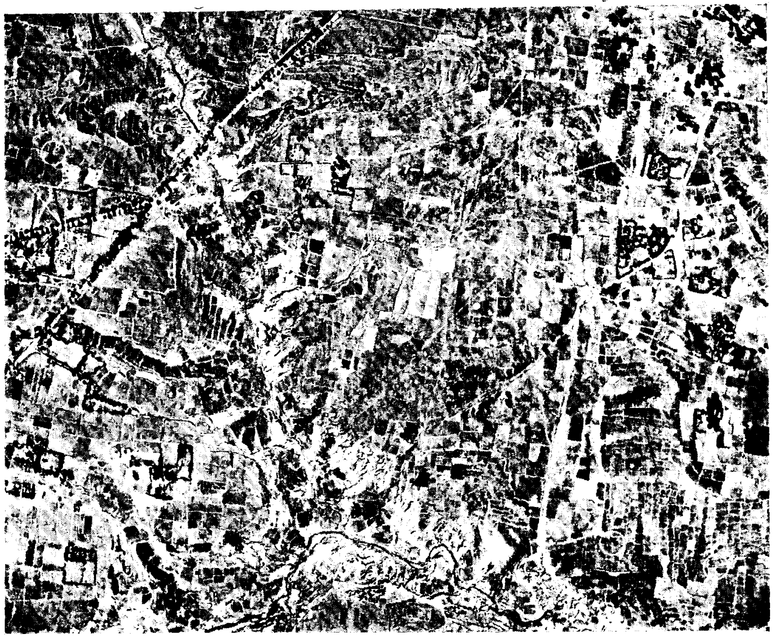


Fig. 1 B 7/4

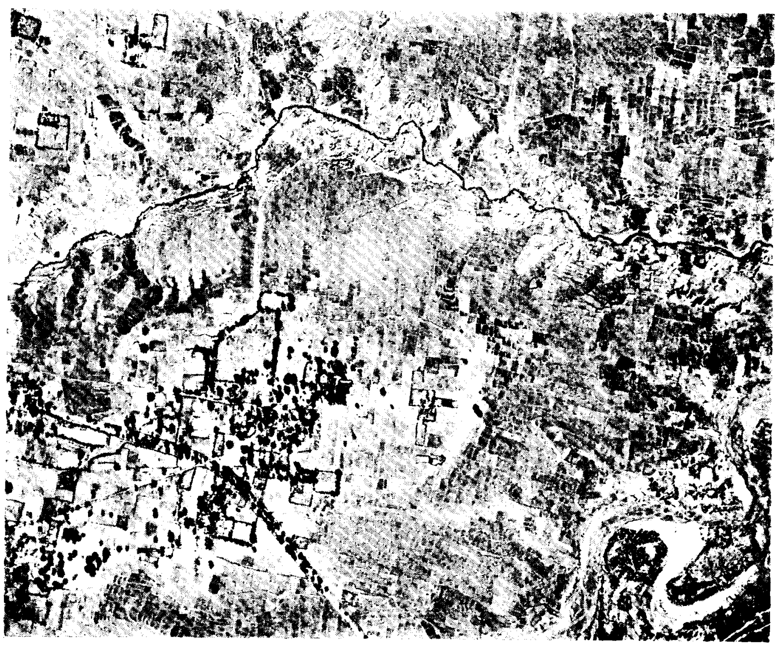


Fig. 2 B 7/5

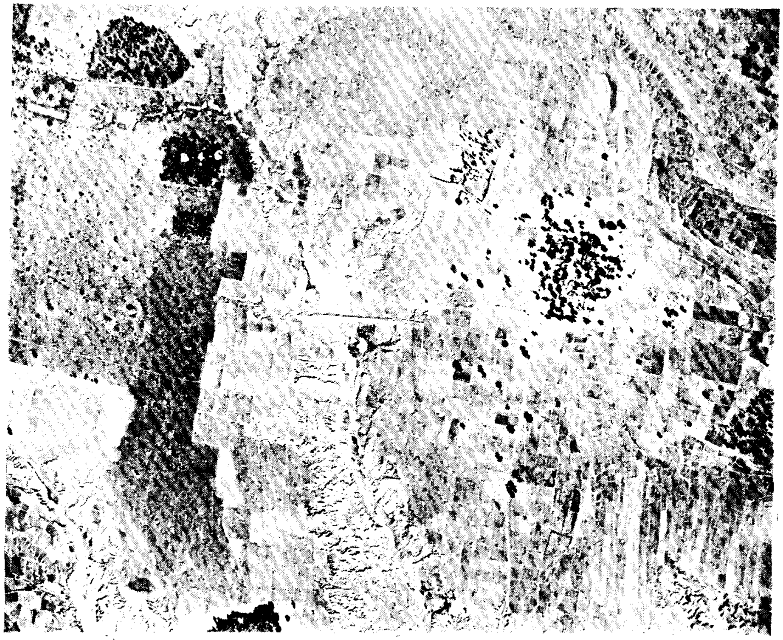


Fig. 3 B 4/6

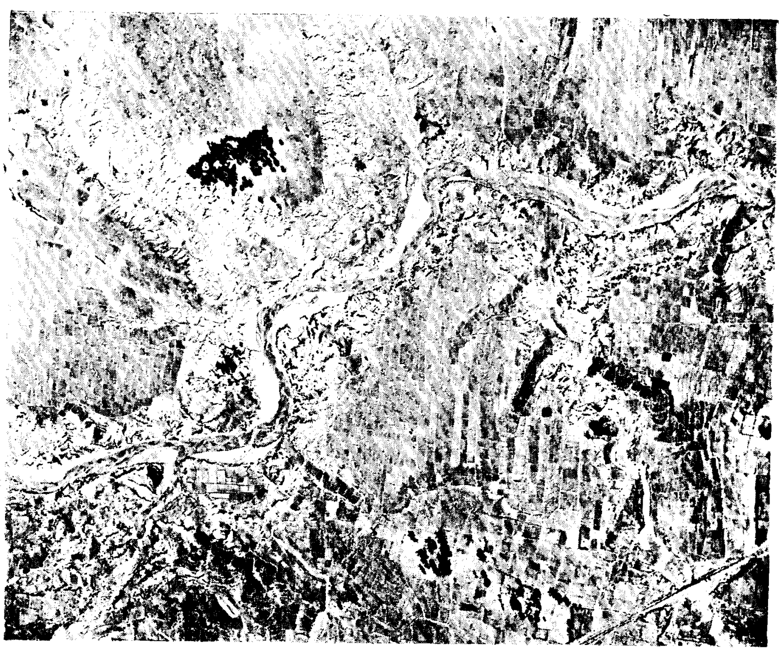


Fig. 4 B 4/7

PLATE 32

B4/6 and 7 (Ranchi).

These two photos are very interesting; they show the havoc that is being wrought by gullies in cultivation near RANCHI. Gully action is active over the greater part, and gulley "fingers" are very clearly shown eating into the land in the angle formed by the two subsidiary torrents which enclose a grove of trees. In B4/6 terracing of fields is markedly absent and it will be observed that the fields surrounding the active gully areas are neither terraced nor have embankments, and show signs of sheet erosion. In B4/7, some terracing and strong embankment round fields has checked gullying near the bend in the main torrent near the bottom left hand corner, while the activity of the torrent running to the bottom right hand corner and its gullies has been considerably checked by the obvious terracing and contour alignment of the fields on both sides of it. The prevention and cure of gullying lies in the levelling and terracing of fields throughout the basin, so as to hold rainfall on the land (low embankments may also be necessary) and *not* in the construction of dams such as that shown in B4-6; when run-off from the fields has been checked, gullied land can be reclaimed and made productive,

PLATES 33 and 34

B6/1, B7/1, B8/1 (Ranchi).

These three photographs depict small sheet eroded hills now standing as almost barren out-crops, with a little scrub growth. Gullying is present around the foot of the hills. Sheet erosion is apparently active at the bottom right hand corner of B8/1 where terracing and embanking of the fields is absent. The gully entering at the bottom of this photograph is the same as that shown in B7/4 and has eaten its way back *six* miles from its source.

Fig. 5 B 6/1

Fig. 6 B 7/1

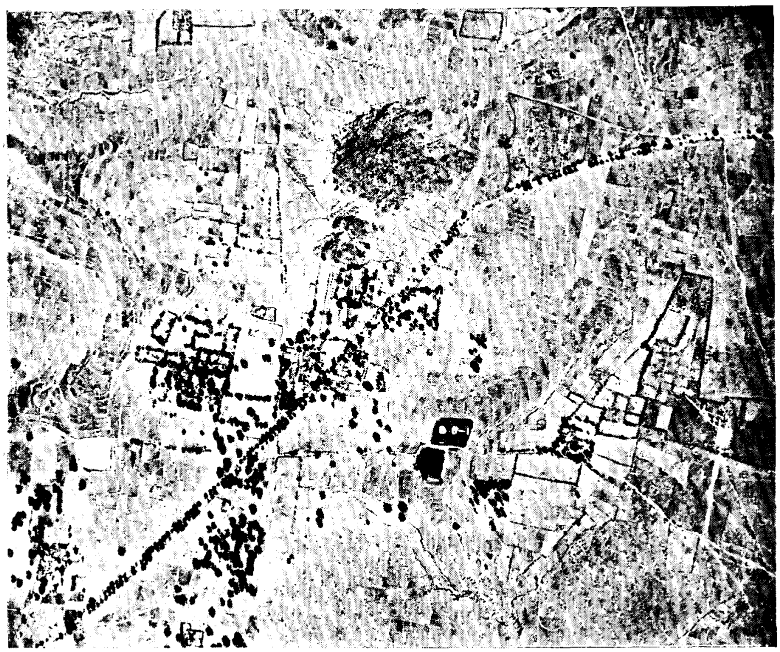


Fig. 7 B 8/1

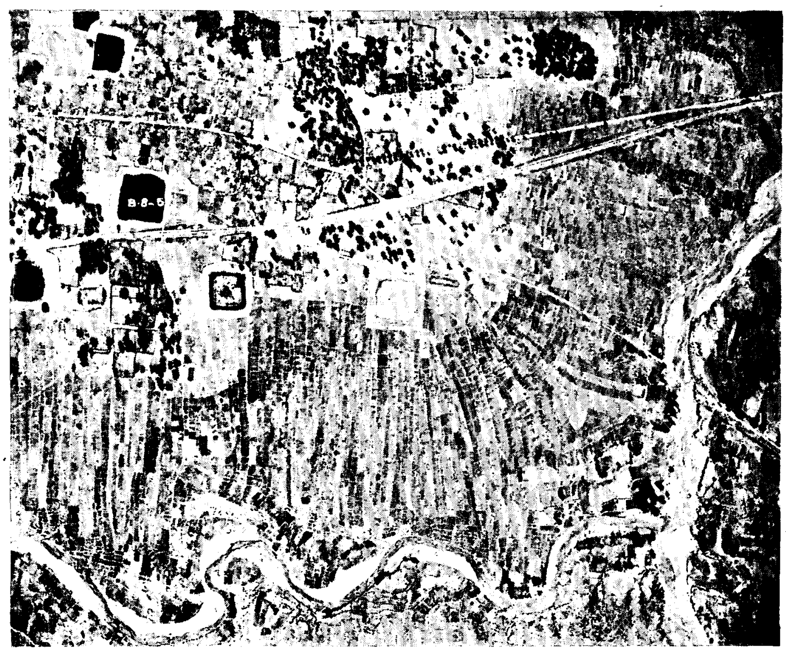


Fig. 8 B 8/5

PLATE 34

B8/5 (Ranchi)

The layout of the fields is interesting. It this case it is probable that the river has slowly moved across the basin allowing the numerous cultivators gradually to extend their holdings. Near the river, where the slope increases, some terracing may be observed on both sides of of the river. Gullying is beginning along the water-course at the bottom right hand corner, where soil conservation measures in the fields have not been undertaken.

PLATE 35

B2/3 (Ranchi).

Around the edges of the forest no cultivation appears to exist except at one point, and sheet erosion is present. This probably originates in the forest which has been thinned out, particularly near the outskirts, and contains mainly scrub. If this forest were properly managed to produce firewood and small timber for the cultivators, the run-off would be reduced and sheet erosion outside its borders would cease, permitting cultivation. The gully to the left of the forest has travelled 1 mile from its source and no attempt is being made to control it.

RT5/5 (Bihar).

The country shown is gently undulating with occasional small hills, which are practically barren. This photograph shows much sheet erosion, little attempt appears to have been made to control run-off, and the land is producing little—a typical area for the introduction of soil and water conservation measures.

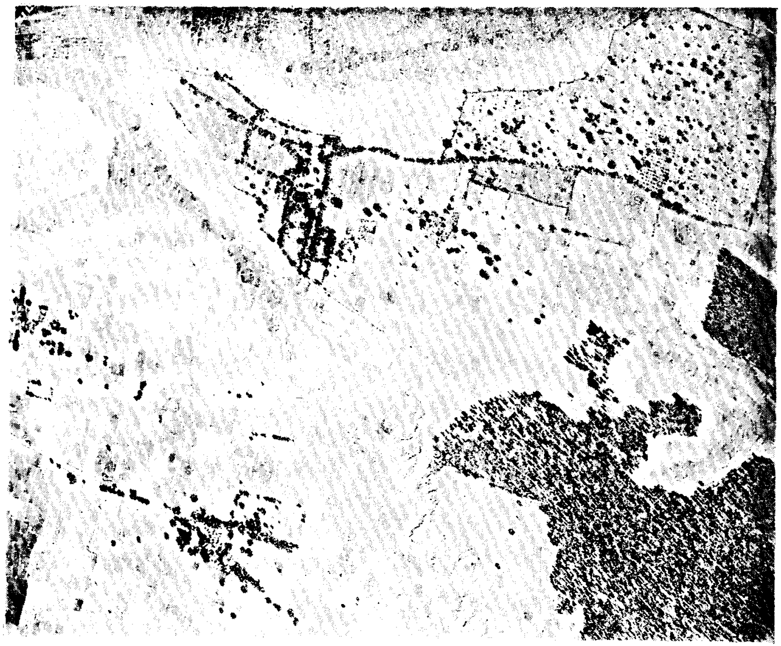


Fig. 9 **B 2/3**

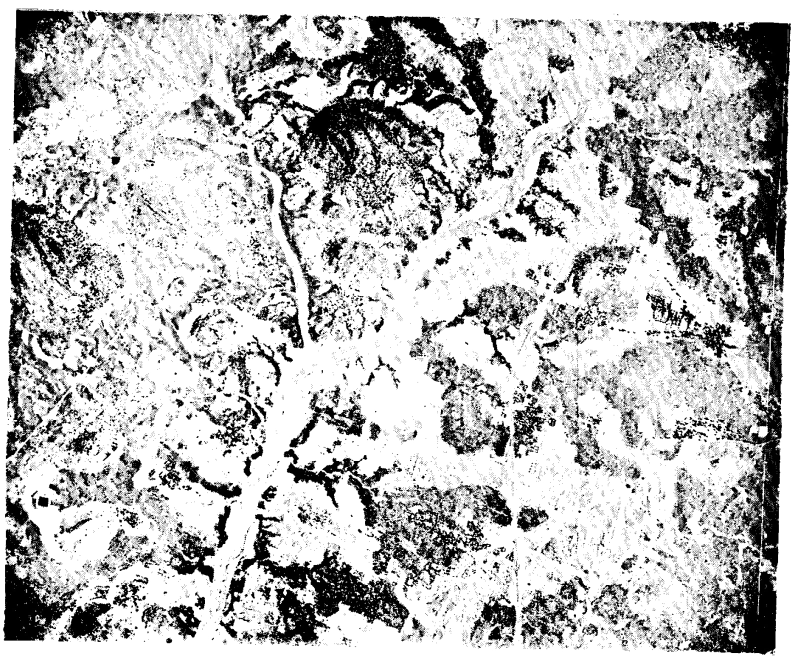


Fig. 10 **RT 5/5**

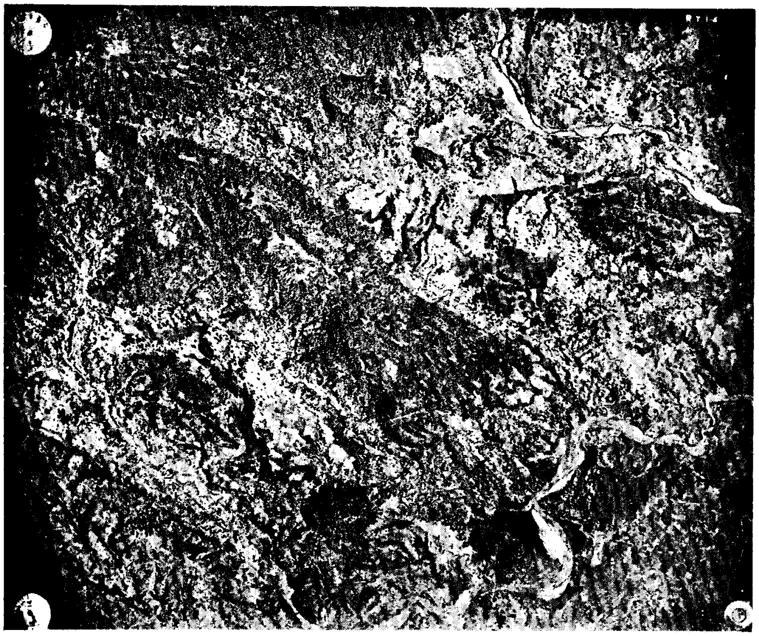


Fig. 11 RT 1/6

Fig. 12 B 2/3/6

PLATE 36

RT1/6 (Bihar).

A picture of disforested hills and surface erosion, only a small amount of scrub remains on the slopes. The basins between the hills are gullied, most of the original alluvium having been eaten away. 75 per cent. of the country appears to be non-productive. The first and most important measure required here is to restore the vegetation on the hills by introducing simple forest management, only in this way can prosperity return to the cultivators.

B2/3/6 (Ranchi).

This photograrh shows the summit of gently sloping land which was once under cultivation and now completely abandoned as a result of sheet erosion. The area photographed was actually visited on the spot afterwards and the interpretation of the air record checked. Much of the land, apparently under cultivation in the photo, had gone out of cultivation or was under such severe erosion that crops were failing; there was an abandoned building and a dry well and desolation was clearly spreading, though some of the land was still salvable through simple soil conservation measures.

PLATE 37

1158/61 (Garo Hills, Assam).

This photograph shows conditions of jungle destruction and erosion which are typical throughout vast tracts of the hills of north-east India and upper Burma. The practice of shifting cultivation, or *jhuming* is responsible for this. The villagers clear, often by burning, areas of fine forest, and after cultivating them for a few years, move on to do the same in other places. Severe sheet erosion is present over a large area to left and the numerous irregular, light toned patches scattered over the forest are shifting cultivation.

T57/9 (Tripura).

Shifting cultivation or *jhuming* in its worst form. The forest has been almost entirely destroyed and nothing remains to hold the soil which will disappear under sheet erosion rendering the country unfit for any further use.

Fig. 13 1158/61

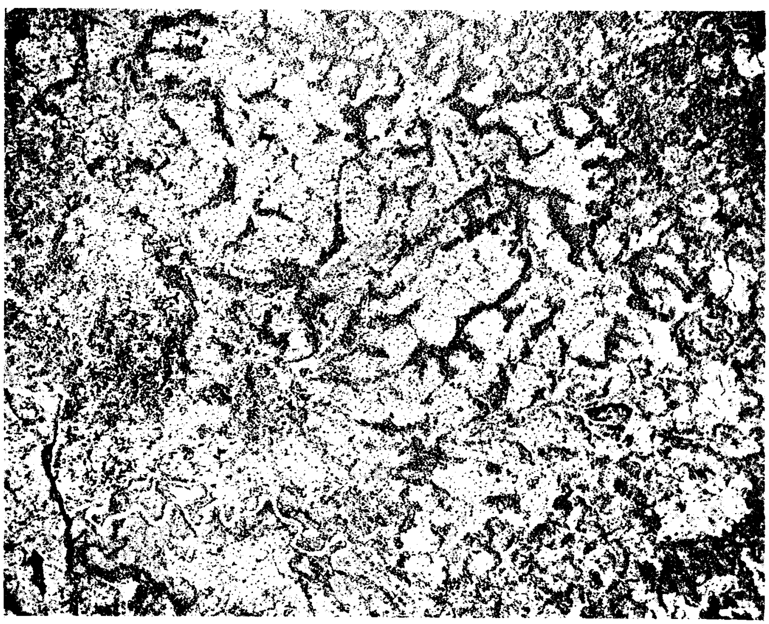


Fig. 14 T 57/9

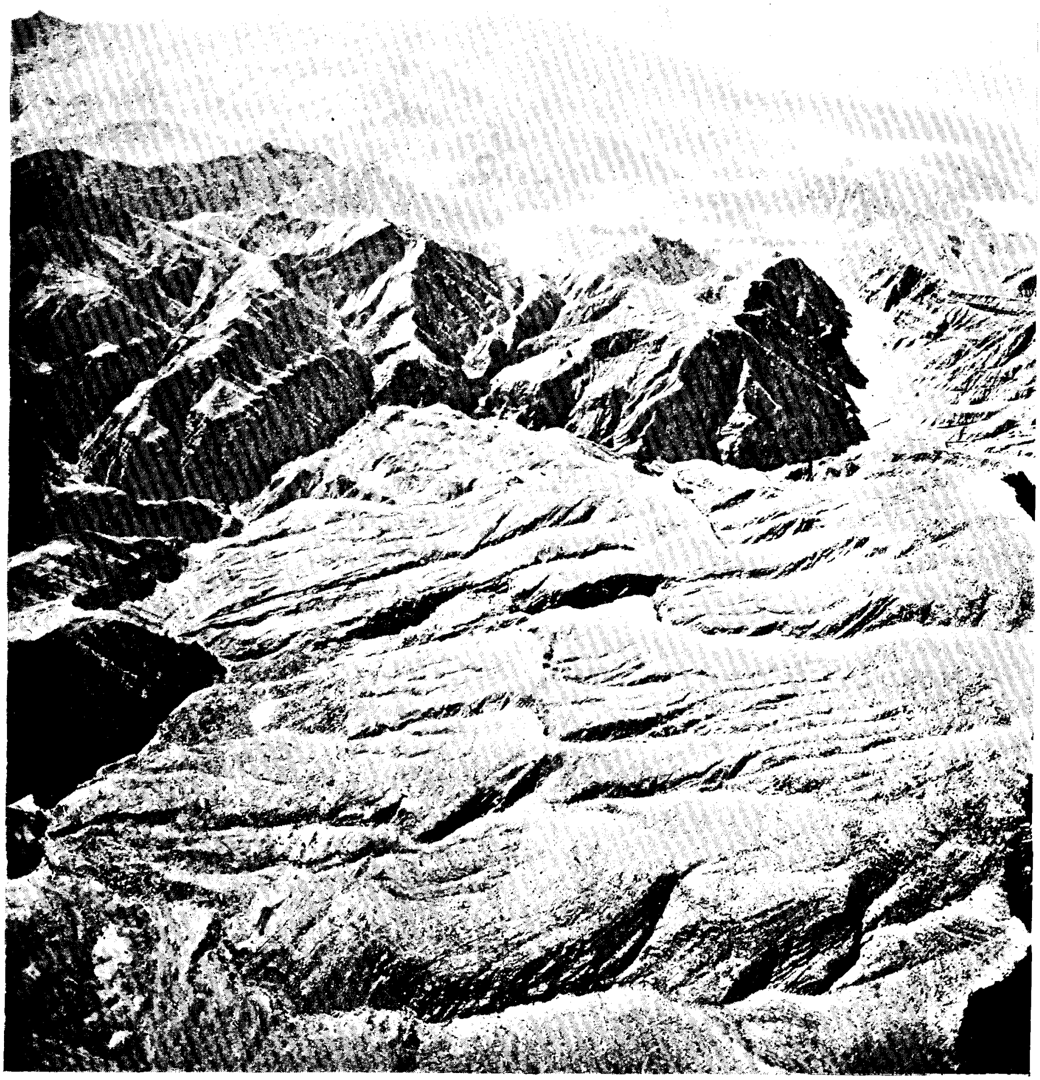


Fig. 15 4/13

PLATE 38

4/13

An oblique photograph showing the final stage of sheet erosion where man cannot exist. A little vegetation can be seen still clinging to the rocks in the ravines at the bottom left hand corner. The Khasi hills in Assam are rapidly approaching this end.

PLATE 39

A2/F5 and 6 (United Provinces

These two photographs show the fine tracery of gully erosion spreading into the rich alluvial lands of the United Provinces. Many examples of fields entirely surrounded by gullies may be seen; they are doomed to disappear in time. The country is nearly flat and the erosion could have easily been prevented if the simple measures required to check run-off from the fields, *i.e.*, levelling and embanking had been undertaken. The photographs show that even now little is being done to check the gullying. The wasted land can now best be utilised for growing minor forest and grass for the cultivators. Sheet erosion is active towards the bottom right hand corner of A2/F5 and bottom left hand corner of A2/F6. In A2/F5 bush-scrub increases in density near the river.

Fig. 16 A 2/F 5

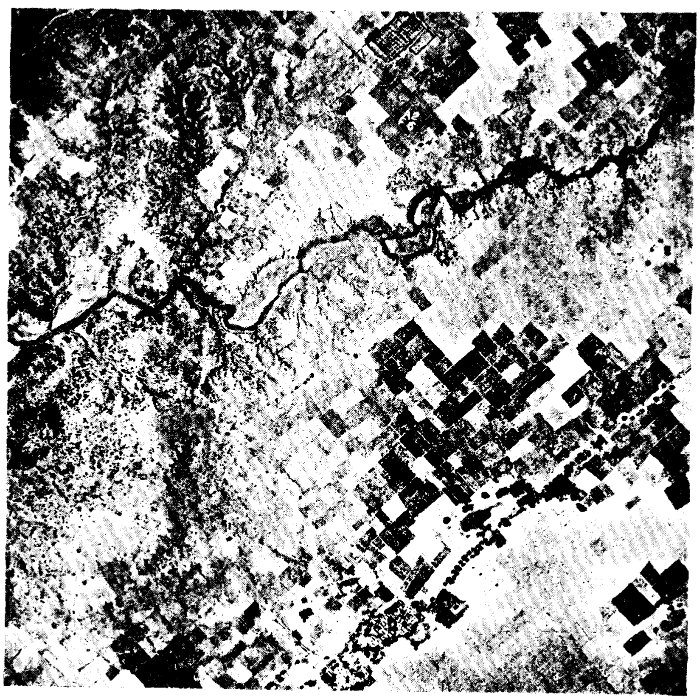


Fig. 17 A 2/F 6

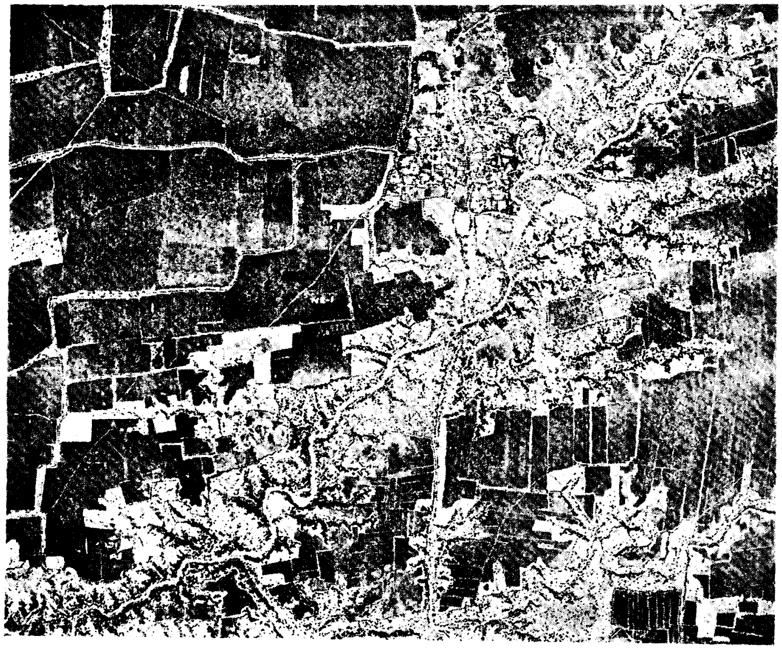


Fig. 18 **N 2/1**

Fig. 19 **N 2/2**

PLATE 40

N2/1 and 2 (The Narbada river).

These photographs show gully erosion in the rich alluvial deposit in the basin of the Narbada river. A good deal of preventive work has been done as can be seen by the hard lines along the borders of the gullies which represent embankments. But little has been done to control drainage on the fields themselves nor has any attempt been made to reclaim the eroded lands.

PLATE 41

BB 1/10 and 11 (Burma).

Typical examples of gully erosion; the large area of cultivation to the left is a plateau and the villagers have attempted to prevent further incursion by the gullies by making a low bund round the perimeter (dark line). The remains of fields are to be seen on the higher ground scattered about the eroded area, from which all traces of vegetation, except a few bushes, have disappeared; the whole of this tract ought to be closed and reforested.

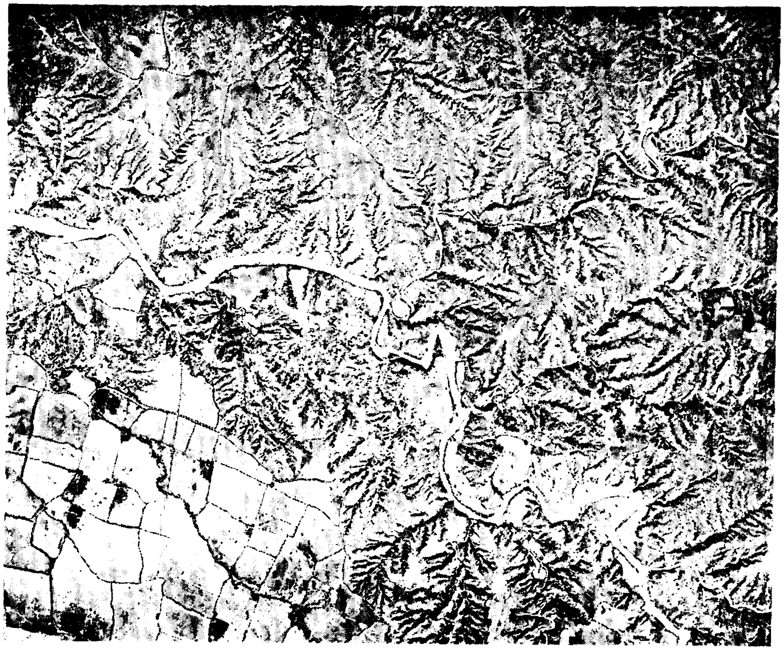


Fig. 20 BB 1/10

Fig. 21 BB 1/11

Fig. 22 BB 1/19

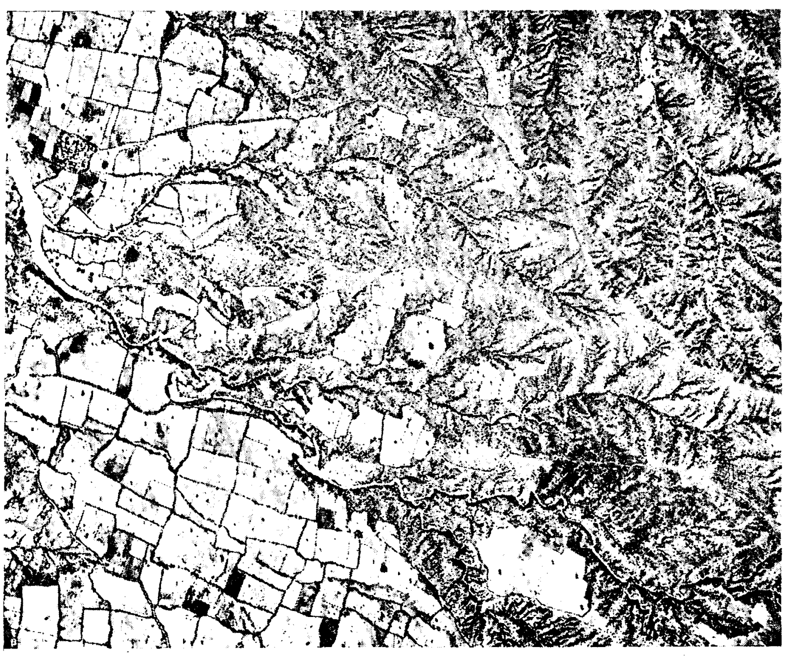


Fig. 23 BB 1/20

PLATE 42

BB1/19 and 20 (Burma).

Here again the villagers have attempted to check gullies by surrounding their fields on the higher ground with low *bunds*, but what a lot of valuable land has already been lost.

PLATE 43

U3/3 and U4/3 (Central Provinces).

In the Central Provinces there are vast tracts of undulating or hilly ground with poor, shallow soils; sheet erosion is probably more serious than gully erosion owing to climatic and geological conditions, and the necessity for preserving the top-soil and rainfall is a matter of the greatest importance in order to raise the already dangerously low soil fertility.

These two photographs are not really typical of prevailing conditions. In U3/3 the fields appear to be getting smaller, the waste land between them increasing owing to sheet erosion. This waste is probably used for grazing, but it cannot provide much fodder. In U4/3 scrub can be seen growing in the gullies and it will have done something to stabilize them. Both this photograph and U3/3 afford good examples of bad and wasteful utilisation of the land.

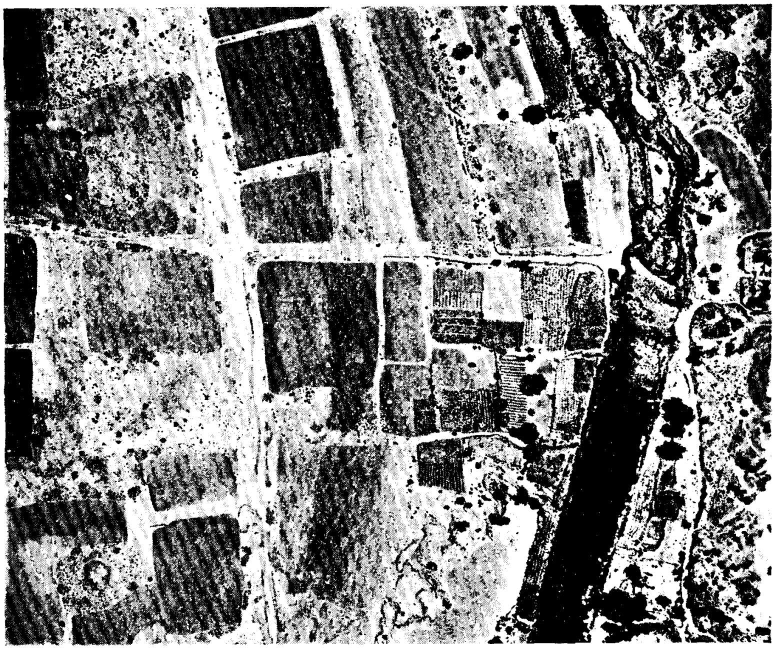


Fig. 24 U 3/3

Fig. 25 U 4/3

Fig. 26 MET 1/3

PLATE 44

MET1/3 (Burma).

Sheet erosion on sloping ground near Meiktila resulting from the destruction of forest, only the vestige of which remains.

APPENDIX

EXTRACTS FROM THE PROCEEDINGS OF THE BRITISH EMPIRE FORESTRY CONFERENCE, SOUTH AFRICA, 1935.

"II. FOREST AND WATER CONSERVATION."

(*b*) *Run-off.*—It is impossible to divorce water conservation from climate. The first influence of the destruction of the forests is on the moisture content of the land, the diminution of perennial streams, the increase of floods, the deposit of detritus by wind or water, and the gradual reduction of cultivation. All this is followed by increasing aridity, by the greater desiccating effect of wind, by increasing severity of climate, until the land will no longer support a wealthy and prosperous population. Poverty grows with the deterioration of the land until the time arrives when man departs leaving a desert behind him.

III. EROSION.

It is unnecessary for us to recapitulate all that has been stated on this aspect of the subject during the debate. It is admitted by all authorities on erosion that one of the greatest calamities which has overtaken mankind has been the destruction of the forest and the consequent erosion of the land surface. This has already destroyed the fertility of many lands and is at the present day exercising a powerful influence on the destiny of the people.

Erosion results from the misuse of the surface covering of the earth, whether it be by the destruction of the forest which covered it, by the misuse of arable or pasture land, by bad methods of cultivation, by burning or by over-grazing. We are chiefly concerned here with the influence of the forest. Erosion caused by faulty methods of cultivation or pasture management we leave to the sister science of agriculture; indeed the Drought Commission has pointed out that faulty pasture management in South Africa is at the present day the greatest factor in causing erosion. Nevertheless, in dealing with the erosion problem the planting of trees can be as beneficial in South Africa as in other countries confronted with the same problem. Erosion is worse in countries of low rainfall and hot summers than where ample rainfall covers immediately any bare surfaces with vegetation. The conflagrations which rage throughout the savannah forests of Africa gradually end in their destruction. The heat of the sun, hot winds and the trampling of stock pulverise the surface soil, which is then blown away by the wind or washed away by the torrential downpours which generally follow prolonged periods of drought. In this way the whole top soil may gradually be eroded away in the form of sheet erosion, leaving an unfertile sub-soil from which man can at the best eke out a miserable existence. Thus the destruction of the savannah forest leads imperceptibly to the desert which can support neither man nor beast.

The geological formation exercises a powerful influence on the rapidity of erosion. Once denuded of their natural covering, land such as the tertiary formations of the outer Himalaya and the red earths of Africa are eroded with appalling rapidity; likewise the loess plains of the prairie provinces of North America are rapidly ruined by sheet erosion and gullying; so much so that large areas of cultivated land have been abandoned as impossible of repair, and the sky for many hundreds of miles in North America has been darkened by clouds of top soil being blown from farms of the prairie region. The illustrations in the papers submitted to the conference and to be found in any work dealing with this subject will show a land surface utterly destroyed by gullying caused by the rush of water on a denuded soil. There is evidence however, from all over the world that even where erosion, especially sheet erosion has actually commenced, it is possible to remedy the position by preserving the natural vegetation and by afforestation. Where extensive gullying is already present, afforestation must be combined with engineering operations of a minor nature such as the construction of small dams, fascines, etc. The combination of such engineering operations with the protection of the soil from burning and grazing, together with afforestation can deal with the problem.

Statements have been made in South Africa that wattles and eucalyptus promote erosion. This is entirely contrary to fact so far as the Government and large private plantations under proper management are concerned. All those plantations are covered with a thick layer of vegetable detritus, and, in the case of wattles the piling of the brushwood in contour lines subsequent to clear felling entirely prevents soil erosion. The accompanying photographs, Annexure VI, illustrate the method and effects of brush piling. Nowhere have we seen the

least indication of erosion in these plantations, nor is the ground bare of cover except on fire lines which are rightly swept clean of all such material as a precaution against fire.

We must repeat that too often the erosion problem is considered from the wrong end, and large engineering works are conceived for the mitigation of this evil, whereas the problem should be tackled at its source in the hills, and cured by the generally inexpensive measures of nature, rather than by the costly construction of mankind.

Enough we consider, has been said during the discussion of this subject to point out the beneficial effect of the forest as a natural cover of the surface of the earth and of the disastrous results of the destruction of such cover. Whether it be on the mountains of the Himalayas, the highlands of Australia, the savannah forest of Africa, or the plains of North America, wind and water, unrestrained, exercise their powers of disintegration on the denuded surface of the earth, ruining land laboriously prepared for the satisfaction of the needs of mankind and rendering once fertile areas sterile and uninhabitable.

In the debate Mr. C. G. Trevor (India) said the following:—

"In opening this debate, I would draw attention to the papers which have been submitted to this conference. I hope you have them all before you, including the excellent contribution by Mr. Stockdale, the Agricultural Adviser to the Secretary of State for the Colonies. I have many times been likened to the prophet Jeremiah who spent most of his time preaching evil things to a sinful world. Prophets are generally cordially detested, governments view them with suspicion, and the crowd who are accustomed to listen to the honeyed words of politicians telling them that they are the heirs of all the wisdom of the ages, resent having the follies of mankind and the inequity of their ways pointed out to them. But generally speaking, it must be admitted that prophets have prophesied what has come true, however much they may have been disliked in their lifetime. No doubt Jeremiah can now turn round to his contemporaries in the place where he has gone, and say to them " I told you so," if that is any consolation to him.

Now, gentlemen, we are called upon to discuss a very serious problem. Ever since our arrival in this country the importance of erosion has been placed before us by all the public speakers to whom we have listened, and it is a good sign that in this country at any rate, public notice is being taken of the evils of erosion and of the importance of taking steps to do something to mitigate this evil, and the future dangers that will be entailed by a policy of neglect. Representing as I do one of the older countries of the world, I propose in the short time allowed to me to give you a picture of the result of disforestation in the ancient world. If you read history, you are bound to believe in the prosperity of these ancient kingdoms and if you compare that ancient grandeur with their present decay, and their ancient wealth with the amount produced to-day, you can only be driven to one conclusion, and that is that the present decay of these countries is very largely based on the deterioration of the moisture that lies in the earth. Now, just imagine for a moment, what has happened to Persia for instance. Take the palace of the King of Kings, Darius, who at one time reigned practically over the whole eastern world. Can you imagine a man occupying his position, building his palace in the desert. But to-day, if you see the ruins of the palaces of Darius in Susa, they stand in an uninhabited wilderness. Mesopotamia, which for generations produced all the revenues of Persia, by which that country was able to wage war against the Romans, has degenerated into a dreary waste and the hanging gardens of Babylon are a rubbish heap. No doubt the degradation of Babylon was partly due to the destruction of the irrigation works by the invasion of the Mongols, but already at that time, the irrigation system of Mesopotamia was in a state of decay on account of the destruction of the forests on the hills, and the bad regime of the Tigris and Euphrates which supplied the water for the finest irrigation system in the world, a vast system with which the Punjab at the present day cannot compare. The same history is repeated all over the world. In Greece, Anatolia and Spain, the destruction of the forests had seriously interfered with their climate, with their cultivation, with the moisture content of their soil, on which in the ultimate end, every nation and every kingdom depends. So much has this been the case in ancient history that it has been stated that disforestation by the lowering of the moisture content of the soil, thus decreasing the water supplies of the country, has done more damage than any war, and has resulted in the destruction of the greatest empires. I do not intend to-day to do more than pass in survey the history of the ancient world.

My colleagues from India, from Canada, from Australia and from Africa, will deal with the effect of disforestation in their own countries. I will confine myself to a few words about the effects of disforestation in India of which I have personal knowledge. Before the advent of the British in India, the area of forests was very considerable. Cultivation was precarious, and the keeping of livestock was a hand to mouth existence, because a man never knew how long he would be able to keep his cows, owing to wars and famines. Consequently, the destruction of forests did not proceed at any great speed. It is chiefly due to the introduction of peace in India, owing to the British occupation, that the population there has vastly increased, and that far greater demands have been made on the forests for cultivation, for firewood, for grazing and for one thing and another, so that the destruction of the forest area, or rather the diminution in the area of the forests within the boundaries of India, has been going on at a very great rate, during the last 150 years.

To give you an instance, when the Emperor Jahangir built the castle of Nurpur for his queen, Nur Jahan, the Light of the World, he writes in his memoirs that the forest was so thick that a bird could hardly spread its wings.

But if you go to that place to-day, you will see nothing but a denuded hill country, with hardly more than a few tufts of grass and thorn bush, on which a few goats eke out a miserable existence. All that has happened in a period of not more than 300 years; in that time the dense forests which clothed the outer Himalayas have been reduced to a negligible amount. The Rajah of Kangra, himself the descendant of a very ancient line of kings, told me that they still point out where the *machans* or shooting butts were placed in the days of the Maharaja Sansar Chand. To-day those surroundings are as bare as this floor, there is hardly cover for a hare, let alone for a deer. It was in 1852, after the annexation of the Punjab, that we in our enlightened manner gave away all the outer hills to the villagers. Before our kind action in this respect, they were the hunting grounds of the nobility, but having conquered the country, we thought it expedient that all the waste land surrounding the villages should be handed over to those people for their mutual benefit. But what have they done? They have utterly destroyed the whole vegetation of the hills by burning, cutting, and grazing. I would ask you to turn for a moment to the illustrations at the end of the paper for India, which are more eloquent than any words of mine, of the appalling consequences of such action. You will see from those illustrations on Plate 1, the entirely eroded surface of the outer Himalayas. You will see the remains of the vegetation, and if you turn to Plate II, you will see the cattle endeavouring to obtain some sustenance from the so-called grazing area. In the bottom picture you will see an assembly of the local villagers, protesting against the closure of their particular area of grazing, and if you examine the ground you will see that there is on it not a living thing, not a living leaf on the tree which has been lopped to feed the last goats.

If you will turn to Plate III, you will see what you might imagine to be a watch-tower, but it is not. It is a well. When it was built it stood in cultivated land. The level of the land was naturally where you see the top of the well, and what you see before you is the remains of the well standing in a dry and sandy river bed. All this is entirely due to the erosion and denudation which has taken place on the outer hills to the Himalayas, subsequently to the year I have mentioned, when these areas were kindly given away to the local inhabitants to do what they liked with.

Erosion may be summed up as ill-treatment of the surface of the soil. (Hear, hear). Whatever the cause may be, and there are several causes; first of all in my opinion, comes the destruction of the forests by mankind which has so often turned a garden into a desert.

Now, gentlemen, before I close, I would like to commend to you a few words from the preface to the *Arabian Nights*. "The lives of former generations are a lesson to posterity, that a man may review the remarkable events which have happened to others, and be admonished, and may consider the histories of the peoples of preceding ages, and all that hath befallen them and be restrained." If you and the governments of the countries you represent will only realise this fact, and will consider the histories of peoples of preceding ages who have destroyed the virgin covering of the earth and what has in consequence befallen them. If you will take steps to see that in the enlightened days the same fate does not overtake us as has overtaken other nations, perhaps in a thousand years from now, the world will be in a better condition than it is to-day.

Mr. Roberts (Union of South Africa): As Dr. Reynecke has mentioned, this debate has come at rather short notice, and therefore I am not very well prepared. But I speak as an engineer, who is interested in anti-soil erosion work. I have really only one point that I wish to bring out, and that is this, that from my own observation forestry as generally practised consists of trees planted fairly close together in regular formation, and apart from the pines that make a fairly extensive litter underneath, the gums and similar trees cause the ground beneath them to become totally bare and dried out to a very great extent. Now, one of the earliest speakers this morning mentioned that in Nigeria, I think it was, in the high rainfall area of 360 inches, peculiarly enough the erosion was less due to water than in the other area where the rainfall was only ten inches. Well now, that is exactly our own experience, and I put it down to this fact, that if soil is kept continuously moist to a certain degree, the root systems of the smaller plants never entirely die out, and when storms come, the soil is bound together by these tiny but all-pervading root systems. Our trouble here is where you get a semi-arid area, and where everything grows well including grass and small shrubs until, you get a drought, and then these small roots die, after which you are at the mercy of the first storm that simply rips out the whole area. That is the trouble. So that I feel very strongly, partly from the point of view of anti-erosion work that our indigenous bush in South Africa has enormous advantages. In the first place, speaking subject to correction, I believe that our indigenous trees do not draw on the water in the soil as heavily as some of the exotic species. Secondly the growth is such that they do not stand alone. As trees, they are accompanied by all forms of shrubs, grass and other vegetation, which blend together and form a more or less a complete protective mat, and therefore, I wish to suggest that every possible attention be given to the possibility of bringing back our indigenous bush with its accompanying vegetation wherever possible.

Mr. J. B. Clements (Nyasaland): It may be of interest for me to mention that in Nyasaland, an important factor in the cause of dessication and erosion is the physical changes which takes place in certain soils after they are put under cultivation, and this particularly applies to lateritic red loams and ferruginous soils, which are very extensively distributed in the Protectorate. They soon become crusted, resulting in a very much reduced power of absorption, and an increased run-off of rain water during the short rainy season.

Mr. E. A. Garland (India): In opening this debate Mr. Trevor referred to the remarkable destruction that had taken place in India and other countries by the denudation of forests. My sole excuse for occupying the conference is that I should like to augment what he said with a few facts, referring to a case in India where it was found definitely possible to check erosion and to improve soil condition by good treatment.

Before giving those facts, I want to emphasise that point of good treatment. A negative policy of no treatment is definitely found to be useless. Certainly in the presidency which I come from, that is Bombay, and I think possibly elsewhere, forest conservancy in its early years was rather too inclined to a negative policy. That is to say, they said that simply stopping grazing would be sufficient, that the tree growth would come in again, and we should be able to clothe our bare hillsides with what we wanted. Unfortunately, although that might have been the case in the course of years, the process was excessively slow. Denudation and the general destruction of vegetation had gone so far that the process of reconstruction was extremely delayed, indeed almost invisible. Whether land is best utilised as forest or pasture is a matter of ecological status and economic conditions and the basis of such utilisation must be a detailed survey and careful land classification.

Now to turn to this particular instance, of which I wanted to give a few data. At Poona, which is the summer capital of the Bombay presidency, we had an area of about 40 acres, which the forest department had fenced and closed to grazing. The area remained closed I believe for about 40 years, and the result was almost negligible. The climatic conditions were that there were about 24 inches of rainfall, and the area was situated on the tension belt between the thorn scrub and mixed deciduous forest. The vegetation consisted chiefly of thorn species with a few very scrubby mixed deciduous species, and a great deal of the very inferior grasses, the *Aristidae, Andropogon contortus* and so forth. There was a definite amount of erosion which was steadily increasing. This erosion was creeping up the small

nullahs, or the *dongas* as you would call them in this country. It was gradually creeping up the hillside. Then, in conjunction with the Agricultural Department, we started an experiment of controlled grazing in this area. The Agricultural Department also built small stone walls, very low indeed, along the contours in places where there was any sign of erosion and divided the area into paddocks. First of all, in the first year, they put ten cows into this paticular area. After about three months the poor things were so hungry that they jumped out and ran away. They then divided the area up into four paddocks, three of which were grazed in rotation, and one kept for cutting grass and making hay. When I say in rotation, there was no fixed rotation at all. The animals were simply moved from paddock to paddock, as the grass was used up. They were grazed as closely as possible in each paddock, and then moved on to the next. Well, the result of that treatment in five years was that they were maintaining on that particular area 20 cows throughout the whole year in very fair health indeed. But the point which is of particular interest was that the vegetation had been definitely inproved. The *Aristidæ* and the other inferior grasses had almost entirely disappeared, and very much better grasses such as *Anthisteria ailiata* and *Andropogon pertusua* had taken their place over the entire area. But it did not stop there. The forestry object was also being achieved. The state of vegetation and succession had been so much improved that in spite of this very heavy grazing the natural regeneration of our mixed deciduous species and particularly the *Terminalias* began to make its appearance. Moreover erosion had been checked. So that in five years we had reached the stage in which the soil had been so much improved that it would be possible to decide on the economic point of view, whether we desire to carry on with our natural vegetation and turn it into a small fuel supply area, or whether it was desirable to assist the milk supply of the city. For a small scale experiment I think the conference will agree that it is interesting, and the details have been published, in a bulletin by the Bombay Agricultural Department".

EXTRACT FROM DATA COMPILED BY THE FOREST COMMITTEE OF WESTERN BENGAL

Under the heading of erosion in other countries the report contains the following :—

Erosion in China

China is another country where erosion has proceeded on a colossal scale. The loess soil of North China is said to be the most erodible soil in the world ; gigantic gullies, 300 feet and more in depth, are cut in it by the torrential streams and "present some of the most striking pictures known of the power of erosion". The Yellow river which drains this area carries away each year about 2,500 million tons of soil, sufficient to raise by 5 feet an area 400 square miles in extent: some of this is deposited as fertile soil but the gain "is insignificant compared with the losses from floods, famine, and desolation produced in the densely populated plains by erosion". In many parts of Central and South China whole hillsides have been completely eroded: whole districts have been rendered almost barren: the farmers "commonly burn all forest and bush land each year to destroy hiding places of wild beasts or so that the ashes may be washed down to fertilise the paddy fields in the valleys," and this prevents natural forest reproduction which would check the erosion. In South China sheet erosion has been particularly severe; the original surface soil and upper subsoil has been left exposed to gully erosion. In North China there is wind erosion: and the extension of cultivation on the sandy regions bordering inner Mongolia is producing a new source of dust and leading to the gradual encroachment of the desert.

Miscellaneous instances of water-erosion

It would be an unprofitable task to summarise in this report all the information available as to soil erosion: but lest anyone should imagine from the instances already quoted that only wind erosion is of real importance, it seems advisable to mention some more countries where the destruction of forest has led to erosion by water action. Among these are practically all the lands lying round the Mediterranean sea. Originally well wooded they are now devoid of forest, except in the south of France and the north of Italy: the soils are for the most part such as are easily

eroded after the torrential rains which fall in the winter: and much of the original surface soil has been washed off the land and carried down into the sea. North Africa where there were fertile corn fields in Roman times is now largely desert. In the French Pyrenees there has been "almost catastrophic erosion". In Cyprus since the destruction of the forests "the numerous streams and winter torrents rushing down from the mountain ranges during the rains remove enormous quantities of soil which are either distributed over the plains as a thin layer of very erodible silt or carried out to sea". Conditions in Greece are similar. In Asia Minor "deforestation combined with high rainfall" has led to serious erosion along the south of the Black Sea: there is erosion on the west and south coasts and in Central Anatolia also where the torrents bury rice-fields beneath the detritus carried down by them. In Palestine the destruction of many of the scrub forests which used to cover the hills has been followed by the complete removal of the soil and the complete cessation of springs over large tracts of country: and erosion is so widespread that the chief aim of the Department of Forests is to deal with it.

Water action is the most important factor in regard to erosion in Ceylon also. "Intense falls of rain are the main cause of much serious erosion....particularly where the land is at all undulating and the natural surface vegetation has been removed". In the Dutch East Indies erosion and particularly sheet erosion are of importance: they are associated with deforestation, "which has assumed catastrophic proportions, chiefly owing to the unsystematic clearance of land for agricultural purposes". In the Philippines "catastrophic erosion in places is serious", according to Professor Pendleton, "short rivers with steep gradients carrying with them a vast amount of material eroded from the land surface." In Japan erosion by water which carried the debris over cultivated land has been held in check only at vast expense. In Tasmania during heavy rains large quantities of the red, brown and chocolate soils are frequently removed from the sloping ground. "Often as much as one inch of surface soil may be removed in a rain storm." Instances have been observed where over a period of years the whole of the surface soil has been removed, either being washed into streams or lodged lower down the slope. Owing to the slight change in colour between the surface soil and subsoil in these areas, and to the fact that the type of soil removal is generally sheet erosion, this loss of surface soil is not readily detected by the untrained eye. Similar examples might be adduced from almost every part of the world, except South Africa regarding which the committee have no data. But they will quote here only one more before dealing with examples from India. It will be necessary later to quote some figures collected by Russian scientists as to the observed rate of erosion in the Soviet Union where it is fairly extensive and has been increasing since the land was handed over to the peasants: "there are huge regions in the U.S.S.R. where .... whole territories formerly under profitable agriculture are now occupied by immense ravines and infertile wastes": that it is water and not wind which is the eroding agent is proved by references to extensive gully erosion.

Erosion in India

R. M. Gorrie, quoted by Jacks and Whyte, has pointed out that the increase of cattle associated with the growth of population in India, in areas where grasslands can persist only under reasonable treatment has caused the disappearance of grass over very large tracts and left the livestock dependent upon bush and tree growth for their day-to-day existence. "In most other countries livestock are maintained on a ration of grass and the bush growth which occurs in the grazing grounds is looked upon as a natural reserve which should be used only in times of acute scarcity: in much of India the last vestiges of shrub growth already form the ordinary daily ration for the village herd. The amount of erosion caused directly through this state of affairs has to be seen to be believed." The most serious erosion is evident among the Indian foothills and their outlying slopes where gullies and floods are devastating large areas. "When the Emperor Jahangir built the castle of Nurpur for his queen, Nurjahan, he writes in his memoirs that the forest was so thick that a bird could hardly spread its wings. But if you go to that place to-day, you will see nothing but a denuded hill country with hardly more than a few tufts of grass and thorn bush on which a few goats eke out a miserabe existence." The forests which the nobles in the old days preserved as hunting grounds have been utterly destroyed by the villagers "by burning, cutting, and grazing" and the soil

has been eroded to such an extent that, in a picture shown to the British Empire Forestry Conference by Mr. C. G. Trevor, now Sir Gerald Trevor, late Inspector-General of Forests in India, from whom the above remarks are quoted, a masonry well stood high above ground level like a watch-tower. The surface of the land used to be level with the top of the well and the cultivated land in which the well was made has become a dry and sandy river bed. Mr. Trevor concluded that first among the several causes of erosion came the destruction of the forest. But although erosion may be worst in the foothills of the Himalayas (including those north of Bengal), it is bad in almost every province of India: Central India, the Central Provinces, Hyderabad, Bombay, Madras, Assam, the United Provinces, the Punjab,—in all of these according to the reports gathered by Jacks and Whyte, and in Chota Nagpur and in Orissa according to the Stephenson Committee, erosion has become a serious evil. It is unnecessary to insist on this because everyone in Bengal is aware that the delta is built up of the silt brought down by rivers from eroded areas, in the mountains and in the plains of Upper India: the size of the delta is an index of the extent of the erosion which led to its creation. But it is an interesting fact that there has recently been a formal pronouncement on the subject not by foresters but by irrigation experts: it will be found in *Quarterly Bulletin No. 12 of the Central Board of Irrigation, 1938*, which quotes a resolution of the Board running as follows :—

"The Board is convinced that the evils of denudation in India are so serious and widespread that action for its further prevention should be taken without further delay.

Denudation causes high floods in summer and low river levels and small supplies in winter, which result in :—

(*a*) damage to canal systems through interference with the regularity of canal supplies;

(*b*) harmful deposits of sand;

(*c*) interference with river navigation; and

(*d*) widespread damage to the countryside."

Soil losses from erosion

Soil erosion was declared by the Russian scientist, Pankov, to be a new natural phenomenon created by human intervention. It is natural to inquire how quickly it shows its results. The chief work on this has been done in the United States of America, and in Russia, where there has been in recent years a good deal of careful research on loss of soil by sheet erosion under different systems of agriculture. It need hardly be said that the rate of loss varies greatly according to the slope of the land, the nature of the soil, the quantity and distribution of the rainfall and the extent to which the system of cultivation adopted exposes and disturbs the soil.

The following table shows what different effects result from different methods of cultivation and cropping: it is based on fourteen years' research at the Missouri Experimental Station, Columbia, U.S.A. The soil was loam, the area was 90.75 feet long, the slope was 1 in 27, and the rainfall was 37 inches per annum.

Cultural and Cropping System Followed

—	Ploughed 4 inches fallow.	Ploughed 8 inches fallow.	Continuous blue grass.	Cotinuous wheat	Rotation corn, wheat and clover.	Continuous corn.
Average number of tons of soil eroded per acre per annum ..	41·64	41·08	0·34	10·10	2·78	19·79
Surface erosion in inches per annum	0·291	0·287	0·0023	0·070	0·019	0·138
Average number of cubic feet of run-off per acre per annum ..	46·132	45·836	18·379	35·209	21·129	44·524
Average run-off per cent. per annum	30·7	30·3	12·0	23·3	13·8	29·4
Number of years to erode 7 inches of soil	24	24	3043	100	368	50

Further indications of the effect on erosion of different systems of cultivation are to be found in Q. C. Ayres' book *Soil Erosion and its Control* from which the following figures are taken: they show the average number of days in the year during which the soil is left exposed under each system mentioned

Fallow land	365
Continuous blue grass	..
Continuous wheat	91
Rotation of corn, wheat and clover	73
Continuous corn	207

They have an indirect bearing on the problem of forest management because exposure of soil to weathering will vary quite as much with different methods of forest management as with different systems of cultivation. More direct evidence on this point is afforded by the following summary of the results of experiments on sandy loam in Eastern Texas and Central Oklahoma by Tyler and Guthrie in 1934 :—

Mean rainfall in inches.	Slope.	Cover.	Soil loss in tons per acre.	Run-off per cent.
44·4	1 in 8	Forest	0·01	0·80
		Forest, litter burnt	0·19	2·60
42·3	1 in 11	Grass	0·21	1·50
48·8	1 in 6	Grass	0·00	0·70
33·5	1 in 18	Forest	0·017	0·13
		Forest, litter burnt	0·22	5·06
32·9	1 in 13	Grass	0·24	1·50

These results seem to show that forest as well as good crops of grass afford practically complete protection from erosion on certain types of soil. The effect of burning the forest litter is an increase in the soil loss and in the amount of rain that runs off.

When forest is managed under a system of clear felling the length of the rotation plays an important part. If the rotations are very short, the soil is exposed at frequent intervals and the chances of damage to it are so much the greater: with longer rotations the ground is covered with trees long enough for the natural process of weathering and decomposition of humus and leaf litter to replace the soil which is lost by exposure when an area is clear felled.

In Russia, Pankov found that in typical areas the annual loss by erosion per acre was between 0·8 and 1·2 tons in the north, between 2 and 3·6 tons in the Steppes regions and between 8 and 20 tons in the subtropics. Gussak working at the Tiflis research institute shows that there were average losses per annum of 8 tons per acre on gentle to moderate slopes and 20 tons per acre on steep slopes under plantation agriculture (tea, tobacco, citrus) and that these would result in the complete removal of the surface humus in from 10 to 20 years.

In Ceylon, Holland and Joachim found that under three different methods of cultivation customary on tea estates the loss of soil in six years was 101·8, 56·7 and 92·4 tons per acre, respectively; and, working with Pandittesekere, Joachim found that the Mahawali Ganga, the longest river in Ceylon (206 miles) carried at Peradeniya, not even half way between its source and its mouth, from 130,000 to 820,000 tons of silt per annum. Though the size of the catchment area of this river between its source and Peradeniya has not been estimated, it cannot exceed half a million acres: and the average loss of soil per acre in it would therefore have been from 0·26 to 1·6 tons per annum.

In Tanganyika experiments were undertaken in 1933-34 and 1934-35 to ascertain the run off and the soil loss at the Mpwapwa Experimental Station with the following resusts. The soil was a "coarse sandy friable loam", and the rainfall was 27 inches in the first year and 22 in the second: the rain falls mostly in torrential downpours.

Plot No.	Treatment	*Percenatge runoff*		*Soil loss in tons per acre.*	
		1933-34	1934-35	1933-34	1934-35
1	Bare; uncultivated	52·9	47·8	56·85	59·92
2	Bare; flat—cultivated	34·8	28·2	48·82	54·64
3	Bare; ridge—cultivated	25·2	20·8	12·71*	27·14
4	Bulrush millet (1933-34) *mlama* (1934-35)	29·1	22·9	40·35	34·35
5	Perennial grass	2·8	0·9	..	..
6	Bare; flat—cultivated	33·3	27·1	22·78	15·17
7	Deciduous thicket A	..	0·5	..	..
8	Ditto B	..	0·4	..	..

*This figure for soil loss is for slightly less than half the season's rainfall.

The slope of the first six plots was 1 in 15 and that of the last two, which were added in 1934-35 to obtain data from land under natural vegetation, was 1 in 13.

In East Africa, Cethin Jones considered that large areas under native cultivation on fair slopes would lose 10 to 40 tons of soil per acre per annum, equivalent to a depth of 7 inches in 25 years; and that in places, where there were steep slopes or extremely erodible soil, the loss might be 200 tons per acre per annum or a depth of 7 inches in every 5 years of cultivation. In Nyasaland, Hornby computed in 1930 and 1934 that much of the high land area was losing soil at the rate of a quarter inch per annum: this soil was a comparatively shallow layer of humus over a red subsoil which readily became impervious, and so conditions favoured erosion.

EXTRACTS FROM DATA COMPILED IN RESPECT OF FORESTS IN CHOTA NAGPUR AND ORISSA

"Extension of cultivation is perhaps the quickest method of destroying a forest. At one time it was accepted that the extension of cultivation and the destruction of jungle were unmixed blessings and signs of undoubted prosperity. It might be a matter for consideration whether even in fertile countries the economic results of denudation would not after a certain point outweigh the advantage of extended cultivation; but that question does not arise in the districts under consideration.

In Ranchi even on the steepest hills wherever there is a pocket of soil, level enough to bear a crop, it is generally cleared and cultivated until the soil is washed off or deteriorated by exposure, and the land is unfit for crops or forests.

In the Feudatory States the process of destruction is made more complete by bringing wood from the forest round to burn on the original clearing when the soil begins to deteriorate; the original clearing then becomes the centre of an ever widening circle of desolation.

The other two principal causes of denudation, fire, and grazing, operate by preventing regeneration. The hill-sides and even larger forests are fired more or less regularly each year, partly to improve the grazing and partly that the ash may be washed as a manure on the cultivated fields. This firing destroys the humus thus rendering the soil less fertile, less retentive of moisture, or resistant to erosion; it destroys the seedlings and warps and stunts the young shoots. The damage done by unrestricted grazing is less, but it is quite sufficient to hamper regeneration especially in the case of browsers. As the grazing ground grows less, the damage done by those two agencies will certainly increase.

Loss to agriculture.—The soil in Chota Nagpur is at its best poor, and the destruction of forests must tend to deteriorate it. The subsoil water level recedes, the fertilising humus and leaf manure is lost; cattle have to be fed on the straw which is, therefore, not ploughed into the fields, while the cowdung is used as fuel and does not go to the soil as manure. Erosion gradually covers the fields with sand; this has been noticed at the foot of the Ranchi hills, in Manbhum, and in a striking manner round the Maharparbat hill in the Banki subdivision of Cuttack, where 60 acres have been put out of cultivation in a comparatively short time. Cuttack also suffers considerably from the spill of sand from the rivers in flood. The denuded areas suffer the extremes of heat and cold. In Ranchi there are masses of barren rock from which all the soil has been washed, and on which all the vegetation has been killed; in the hot weather these become so hot as to be unpleasant to touch, and the heat they reflect burns the surrounding fields, and rapidly evaporates all moisture. Both in this district and in Manbhum there are great stretches of barren denuded upland, bare of all vegetation, which to a lesser degree act in the same way upon the cultivated fields. In themselves and apart from their effects, these tracts are economically a waste; in a very few years all fertility is baked or washed out of the soil, and the land is useless for grazing or any other purpose. In Ranchi nearly a sixth of the district is in this condition; there are no recent figures available for other districts, but Manbhum is nearly as bad, and Puri and Sambalpur suffer to a lesser degree. Had the land been left under forest, it would at all events have produced small timber, fuel and grazing apart from any effects on climate or water.

Loss of grazing.—There is no stall feeding of agricultural cattle, and they are, therefore, dependent on grazing; the grazing grounds are the waste lands, fields from which the crops have been cut and jungles. In Orissa, grazing grounds are reserved at the time of the settlement, but even here there are complaints that these have been too greatly trenched on by cultivation, and that the absence of tree shade has been greatly felt. Even in Khurda, with its protection forests, according to the last Settlement Report, there is not sufficient grazing area for the existing cattle. In Chota Nagpur there are no grazing reserves, except in parts of Singhbhum and Palamau, where there are protected forests; the denuded stretches of waste land give practically no grazing, except in the rains the cattle are dependent on the jungles and to chance grazing on the ridges between the fields and by the sides of the watercourses. This effect of denudation has been most felt in Manbhum. Dr. Campbell writes, "At the beginning of the cultivating season hundreds of plough bullocks are in too emaciated a condition to be able to do any kind of work, and the *raiyat* must remain inactive until his cattle getting the new grass regain a little strength before he can put them into the plough. Straw has become so valuable owing to the great demand for it at the collieries that it is sold, and that to the detriment of the cattle who would otherwise have got it to eat." Conditions elsewhere are possibly not so bad as this, because the cattle do in most cases get the straw or some of it, but the deterioration of cattle is a very serious matter in Ranchi also. This dearth of grazing also reacts on the forests, because the remaining forest is more and more overgrazed, and there is less and less reproduction."

EXTRACTS FROM REPORT ON THE POSSIBILITIES OF REAFEORESTATION IN WESTERN BENGAL

"There are extensive waste lands, absolutely bare and of no use to man or beast, except for scanty grazing during the rains, in all these four districts. They are situated on the uplands and slopes of this undulating tract and are a legacy of reckless clearing of jungles for generations in the past. The process of deforestation is still going on unchecked, though not quite in the same spectacular way as in previous generations. The present process is more slow due not to wholesale clearing but due to unscientific management of the forests that renders them less and less dense at each cutting (they are levelled to the ground at very short intervals), useless weeds oust the more valuable species and the jungle recedes gradually. If this process goes on unchecked, the whole tract will ultimately turn into a semi-desert though nothing sudden or alarming need be feared. Nevertheless, there are about 1,000 square miles of absolutely barren land which is unsuitable for profitable agriculture. These are distributed in large and small blocks in almost every *thana* of the western uplands of these four districts.

Mention may be made here of the effect of unregulated forest clearance in different parts of the world.

We know that the sands of the Sahara and Arabia now cover what was once a fertile land, and that many countries such as Greece, Tripoli and Palestine are now only able to support a scanty population. Ancient historians speak of the equable climate of Greece, then densely wooded, and of the perpetual springs of Babylon. Babylonian tablets of great antiquity refer to the attempts to reclaim the country thrown out of cultivation by the sinking of the spring level and erosion, but these efforts were only of temporary benefit. The floods from the mountains increased year by year, the beds of the rivers were scoured out, irrigation became impossible, and the countries gradually developed into their present desert conditions."

BENSKIN—*AFFORESTATION IN THE UNITED PROVINCES*

Many interesting effects of disforestation can be found in almost every country. The United States of America and South Africa have already awakened to this danger and afforestation on a gigantic scale has lately be n commenced in the United States of America. In South Africa afforestation to prevent erosion is an accepted policy of the government. In Great Britain afforestation of thousands of areas has been undertaken during the last twenty years. To come closer home we have the example of the United Provinces where remedy for soil erosion has been sought in the afforestation of the ravine tracts.

Thousands of acres are being converted into forests which not only prevent further erosion but also serve as fuel and fodder reserves for the adjacent villages. In Bombay the measures adopted to prevent soil erosion are the terracing of land and the construction of earth and stone embankments.

In the greater part of these waste lands in Western Bengal the top soil is good alluvium, often fairly deep, which is admirably suitable for tree growth, whereas in others the top soil of alluvium has long been eroded and lost. In such areas preliminary work of a fairly expensive nature will have to be undertaken in order to render them suitable for tree growth. But the proportion of such areas to the better type alluvial covered areas *is very small.* The process of erosion is in some places accelerated due to the practice of raising dry crops on these lands. The landless population or those who have lost their better agricultural lands, owing to their own thriftlessness, as well as due to the activities of the moneylending landlords, often try to get a catch crop from the adjacent uplands once in 3 or 4 years. The top soil is ploughed up and oilseeds or pulses are sown and harvested in the cold weather. The surface soil being thus disturbed is washed away in subsequent years as no preliminary *bunds* or ridges are made, unlike the terraced paddy fields. The process is repeated till the underlying laterite rock (*murrum*) is exposed when the area is abandoned forever. Thus, innumerable barren spaces abound throughout the whole of the Western Bengal tract, distributed as follows :—

District	*Square miles*	
Birbhum	100	Approximate,
Burdwan	100	as exact figures
Bankura	400	are not avail-
Midnapore	400	able.
Total ..	1,000	

Three hundred and twenty square miles of this area should be reafforested with suitable timber and fuel species, bamboos and fodder grasses, as I consider there is no other way of making any profitable use of such a vast area of this nature—undulating uplands—the comparatively inexpensive and natural way of the forester is the solution and not the more expensive way of the engineer (deep tube-wells and the line to provide water for agriculture). The remaining 680 square miles may be set apart to provide for normal requirements of the present and future generations for such activities as horticulture, cattle and poultry farming, and the like and the exercise of grazing rights by the public.

The ownership of these waste lands now rests with innumerable people, *zamindars, patnidars, sepatnidars* and *raiyats*. The owners do not find it worth their while to take up expensive reclamation work, as they do not anticipate it can ever be a paying proposition. Examples of attempts there are, no doubt, where owners construct tanks to collect rainwater and terrace the adjacent lands for paddy cultivation, but in most cases the land so claimed sooner or later becomes waste again. Consequently afforestation by government on a large scale should be taken up on a definite scheme spread over a number of years. The owners should be compelled to make over the land required for the purpose to government under section 36 of the Indian Forest Act. A Minor Forests division should be created with the necessary staff, the details of which are shown in the appendix. Such a scheme of afforestation is not likely to be immediately profitable and I do not consider that it is necessary for government to look too closely into the financial possibilities in the first instance. Nevertheless figures would seem to show that the scheme for afforestation of these waste lands is likely to be remunerative ultimately.

I think a fair comparison may be drawn between the reclamation of these waste lands and reclamation of the sand dunes in the neighbourhood of Bordeaux—Les Landes in France. It is almost inconceivable that the French Government of over a century ago can have hoped to establish valuable coniferous forests on those vast stretches of apparently pure silver sand but the government did realise that it was possible and necessary to check the encroachment of the sand on to the inland cultivation. Accordingly the French Forest Department began to hold up the shifting sand by planting tufts of coarse grass and when these were buried the forest officers planted more. It is easy to imagine the despair of these officers at the apparent hopelessness of their task but they persevere and in the end their patient efforts overcome the forces of nature. The shifting sand was fixed and they began to sow seed. On what was once a rolling waste of malarial sand now flourish dense pine forests,

in which the peasants find ample work behind the shelter of which they cultivate their fields in security.

The work still goes on, and more and more sand is reclaimed, and it is noteworthy that here, as in other very different localities, the French Forest Department is content to go preparing the ground for future afforestation for 20 or 30 years before the sowing or planting of any trees.

This was an extreme case, but no such difficulties will be encountered in Western Bengal where the bulk of the waste lands are quite suitable for immediate afforestation".

TREES

What fun to learn about the trees,
Their Latin names and Pedigrees!
Just now I've got an awful itch
To know what's what and which is which.
At night I dream of good old Brandis
Discovering *Tectona grandis;*
And if of heroes I'd the pick,
Of all I'd choose Sir William Schlich.

The elephant's a noble beast,
He eats a ton a day at least;
They say that he will travel far
For *Tamarindus indica,*
But finds he uses his behind
Too much when eating tamarind;
Kokko he'll gobble, if he can—
Pithecolobium saman.

The *neem* or else (to be exacter)
Melia azadirachta,
Keeps moths, bugs, fleas, cockroaches, ants
And beetles from my Sunday pants.
It's nice to know my mattress comes
From *Bombax malabaricums,*
Or if I should have said Bombaces,
I hope you won't make acid faces.

Some strange effects of trees on me
Are new to science, you'll agree.
Thus I become a lot verboser
When chewing *Cassia nodosa,*
And when the weather fine and warm is,
Then *Xylia dolabriformis*
Gives me the hiccups Paraplegia
I get from *Poinciana regia.*

To other trees I give plus plus,
Like *Pterocarpus indicus*
(Padauk in the vernacular);
It beats ngapi* in scent by far,
And when my Sweetie comes to town,
She sticks great bunches on her crown.
But of all trees, I shall contest,
The alagabin† is the best.

C. J. R.

*NGAPI—A Burmese Delicacy (very dead fish).
†ALAGABIN—Burmese for trees more ornamental than useful.

SUMMARY OF REVENUE AND EXPENDITURE OF THE FOREST

Heads	Ajmer-Merwara	Andamans	Assam	Baluchistan	Bengal	Bihar	Bombay
Revenue— Timber and Other Products—	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Average of three years ending 31st March, 1943 ..	62,390		31,56,508	1,81,935	32,29,554	11,48,761	75,79,860
1943-44 ..	1,37,982		56,29,889	2,51,783	54,92,726	17,97,621	2,13,00,330
1944-45 ..	1,60,394		83,54,124	3,66,606	1,00,01,331	21,94,503	3,13,80,982
Expenditure—							
Conservancy, Maintenance and Regeneration—							
Average of three years ending 31st March, 1943 ..	19,857	Not	9,23,338	1,40,495	10,64,884	1,97,253	22,42,754
1943-44 ..	42,154	Available	24,00,441	2,74,010	24,69,130	2,68,735	92,51,275
1944-45 ..	51,465		73,50,382	3,06,731	*29,95,915	3,27,783	1,67,98,075
Establishment—							
Average of three years ending 31st March, 1943 ..	28,581		8,95,877	43,941	10,75,508	4,00,314	20,97,239
1943-44 ..	27,313		10,45,217	57,502	12,56,538	4,67,338	24,48,654
1944-45 ..	36,484		11,89,696	69,280	15,01,578	5,36,151	27,18,608
Total of Expenditure—							
Average of three years ending 31st March, 1943 ..	48,438		18,19,215	1,84,435	21,40,392	5,97,567	43,39,993
1943-44 ..	69,467		34,45,658	3,31,812	37,25,668	7,36,073	1,16,99,929
1944-45 ..	87,949		85,40,078	3,76,010	44,97,493	8,63,934	1,95,16,682
Surplus (+) **or Deficit** (—)							
Average of three years ending 31st March, 1943 ..	+13,952		+13,37,293	−2,500	+10,89,162	+5,51,194	+32,39,875
1943-44 ..	+33,773		+21,84,231	−80,029	+17,67,058	+10,61,548	+96,00,401
1944-45 ..	+72,445		—1,85,954	−9,404	+55,03,838	+13,30,569	+1,18,64,299

* Rs. 15 lacs transferred each year to the Forest Reconstruction Fund to meet expenditure on forest works during the

DEPARTMENT IN INDIA FOR THE FINANCIAL YEARS 1943-44 AND 1944-45

Central Provinces and Berar	F. R. I. and College	Imperial	Madras	North-West Frontier Province	Orissa	Punjab	Sind	United Provinces
Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
92,73,504	1,92,069	..	55,01,214	12,60,261	9,30,339	49,97,977	10,52,101	96,39,161
1,71,46,545	2,52,839		1,12,99,940	21,00,865	20,92,296	1,17,26,880	35,52,152	1,86,23,590
1,76,90,401	2,62,034		1,40,74,827	14,81,925	34,08,993	1,08,46,860	44,66,701	2,03,14,377
37,74,518	1,60,260	..	16,13,760	4,02,450	3,61,438	18,46,132	67,603	17,51,176
73,47,510	1,39,060		53,25,717	10,15,854	9,47,338	68,87,754*	3,24,189	30,87,450
66,59,698	2,08,875		51,84,571	10,33,637	20,16,288	76,07,180*	6,19,492	40,02,871
21,26,872	6,73,389	52,484	25,05,689	1,88,746	3,69,139	13,06,788	3,27,569	20,34,605
26,20,647	7,95,802	50,988	26,61,184	2,06,319	4,17,622	15,40,247	3,75,985	32,44,934
28,61,055	8,50,978		29,63,465	2,23,172	4,44,385	17,47,655	4,78,520	46,93,540
59,01,390	8,33,649	52484,	41,19,449	5,91,196	7,30,577	31,52,920	3,95,172	37,85,781
99,68,157	9,34,862	50,988	79,86,901	12,22,173	13,64,960	84,28,001	7,00,174	63,32,384
95,20,754	10,59,853	?	81,48,016	12,56,809	24,60,673	93,54,835	10,93,012	86,96,211
+33,72,114	—6,41,580	—52,484	+13,81,765	+6,69,065	+1,99,762	+18,45,057	+6,56,929	+58,53,380
+71,78,388	—6,82,023	—50,988	+33,13,039	+8,78,692	+7,27,336	+32,98,879	+28,51,978	+1,22,91,206
+81,77,648	—7,97,819	?	+59,26,811	+1,62,116	+9,48,330	+14,92,025	+33,73,689	+1,16,18,166

lean years after the war, otherwise the surplus would have been more by Rs. 15 lacs in 1943-44 and 1944-45.

EVIDENCE ON TORRENT RECLAMATION IN HOSHIARPUR

By R. Maclagan Gorrie, D.Sc., I.F.S.

Accompanying an article on the *chos* of Hoshiarpur by B. H. Baden Powell, conservator of forests, Punjab, in the July 1879 issue of the *Indian Forester* is a sketch of the Chohal *cho* as it appeared then (*vide Fig. I, plate* 45). Even at that date this Siwalik catchment of 5,000 acres had poured out sand upon the plains to the north-east of Hoshiarpur town and ruined many hundreds of acres of once fertile land. In this condition it remained until 1939, and photos taken in that year show no appreciable improvement, although from 1905 onwards a large part of the Chohal catchment area was brought under compulsory closure to all animals (1,198 acres) and a further 3,264 acres was cleared of goats and sheep but continued open to cattle. All that could be said was that the *cho* bed had not increased at quite the pace of the former destruction.

From 1939 onwards further complete closures of 1,032 acres hill lands were made on a voluntary basis, and a further 440 acres of the torrent-ruined plains area were closed to grazing and reclaimed by means of the soil conservation technique of live hedges of *nara* (*Arundo donax*) and *banha* (*Vitax negundo*) set at a slight angle towards the torrent. The floods rapidly silt up the intervening gaps which are planted with *kana* grass (*Saccharum munja*) and *sissoo* (*Dalbergia sissoo*). Much of the plains area of Chohal and of a dozen villages downstream has now been brought under closure and the land thus reclaimed now carries a fine crop of *sissoo;* it is this green carpet which has altered the face of the country.

The second sketch (*vide Fig. II, plate* 45) made from the same spot early in 1946 shows the progress which has been made. When it is realised that in the eighty miles between Sutlej and Beas there is a similar *cho* bed every half mile, the improvement thus registered is a real achievement. Not only has the sand been conquered and made productive but many thousands of acres have been brought back into cultivation behind a sheltering screen of forest.

ARTIFICIAL REGENERATION OF BABUL (ACACIA ARABICA) IN SIND

By B. B. Wadhwani

(*Range Forest Officer, Hala, Sind*)

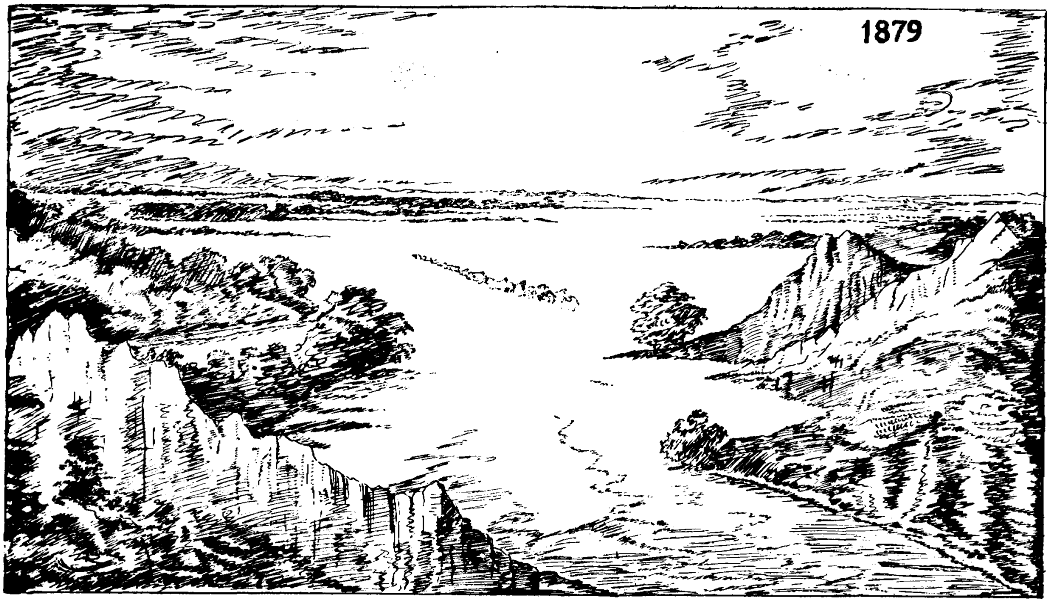
In the *Indian Forester* of March 1943 the writer described various methods of artificial regeneration of *babul* in Sind—seven in all. Since then the writer has evolved one more, which it is the intention of this article to describe. It has been named "Hand Pricking" or in Sindhi *Rote.*

If, after the recession of the river floods, it is found that broadcast sowings have failed totally or partially and while the ground is still soft, these sowings are undertaken. All that is required to be done is that a number of men—depending upon the area to be regenerated—walk along the area in line, lightly pressing 2-3 grains of seed in the ground with their thumbs, roughly 5 foot apart. The seed is at the same time covered to a depth of about a quarter of an inch. This method is next best to broadcasting and takes precedence over dibbling, as described in the previous article, in that it is quicker and cheaper than dibbling. And since the interval between broadcast and "Hand Pricking" is only a few days, the subsequent growth shows very little difference.

Dibbling has been described to "consist of digging pits with a spade, about one foot diameter and 2-3 inches deep". As post-*abkalani* sowing it is supplementary to broadcasting. In order to overcome, to some extent, the disadvantages of this method (post-*abkalani*) it has been slightly modified, as described in the next paragraph.

It will some times be found that in some patches the ground has so dried that it is not possible to do "Hand Pricking," in such patches a small opening is made with a pointed stick, 2-3 grains of seed thrown therein and lightly covered. This stands next to "Hand Pricking" in order of merit.

Fig. I



1879

Fig. II

1946

EXTRACTS

A COLOR REACTION OF WOOD WITH METHANOL-HYDROCHLORIC ACID

I. H. Isenberg and M. A. Buchanan

Research Associates, The Institute of Paper Chemistry, Appleton, Wisconsin

Tests by the authors with 277 species in 56 families have shown that methanol containing a small amount of hydrochloric acid gives a purple coloration when mixed cold with the shavings of some species and not with others. The method gives promise of making it possible to identify the woods of certain species that cannot be separated on the basis of structure alone. The authors will be glad to correspond with any one desiring further information concerning the tests.

In 1936 Isenberg* reported that, when the sapwood sawdust or the total sawdust of white fir wood was heated with absolute alcohol and *p*-toluenesulfonic acid in the Freudenberg method for acetyl determination, a violet coloration first appeared. It has been noted also that, in the case of certain other species (for example, southern red oak), an intense red color developed during this determination. More recently, it has been found that methanol containing a small amount of hydrochloric acid gives a purple coloration when mixed cold with the sawdust of certain species of wood. Although the cause of this color reaction is unknown, it was felt that the possibilities for assistance in wood identification justified a preliminary exploration over a wide range of species, genera, and families, so that suggestions for more intensive studies in the future might be ascertained.

Consequently, shavings from a large number of authentic wood samples were tested with the methanol-hydrochloric acid reagent consisting of 25 ml. of concentrated hydrochloric acid in 1,000 ml. of methanol. The tests were made in test tubes on a small amount of shavings with 5 to 10 ml. of reagent.

Samples from 277 species of 123 genera in 56 families have been examined. Most of these were American woods.

* Isenberg, I. H. Age and the chemical composition of white fir wood. Jour. Amer. Chem. Soc. 58:2,233. 1936

The following is an alphabetical list of the genera (the number indicates the number of species studied if more than 2): Abies (8), Acer (12), Achras, Aesculus, Alnus (3), Amelanchier, Amyris, Anona, Arbutus, Ardisia, Avicennia, Baccharis, Betula (6), Bumelia, Bursera, Callitris, Carpinus, Carya (7), Castanea, Castanopsis, Catalpa, Cecropia, Cedrela, Celtis (3), Cercidium, Cercis, Cephalanthus, Chamaecyparis, Chrysobalanus, Chrysophyllum, Cinnamomum, Citrus (5), Cladrastis, Coccolobis, Cornus, Conocarpus, Cupressus, Cyrilla, Diospyros, Drypetes, Erythrina, Eucalyptus, Eugenia, Exothea, Fagus, Ficus, Forestiera, Fraxinus (6), Gleditsia, Gordonia, Guajacum, Gymnanthes, Gymnocladus, Halesia, Icthyomethia, Ilex (3), Juglans, Juniperus (7), Kalmia, Krugiodendron, Laguncularia, Larix, Leucaena, Libocedrus, Liquidambar, Liriodendron, Lithocarpus, Lycium, Lyonia, Lysiloma, Maclura, Magnolia (5), Melia, Morus, Myrica, Nerium, Nyssa (3), Ochroma, Ostrya, Oxydendrum, Persea, Picea (6), Pinus (26), Planera, Platanus, Populus (8), Prosopis, Prunus (4), Pseudotsuga, Psidium, Quercus (30), Rapanea, Reynosia, Rhamnus, Rhizophora, Rhododendron, Ricinus, Robinia, Sabal, Salix, Sambucus, Sapium, Sassafras, Sequoia, Shorea, Sideroxylon, Sorbus, Swietenia, Taxodium, Taxus, Tectona, Thuja, Tilia, Torreya, Torrubia, Trema, Tsuga (4), Ulmus (5), Umbellaria, Vaccinium, Vitis, Ximenia, and Zanthoxylum.

Many of the samples tested did not give a purple reaction; in some a different color developed, and in others there was no apparent reaction. In certain species the purple color appeared in 10 to 15 minutes, but in other cases it was not evident until several hours had elapsed. For comparison it is best to wait a standard (and sufficient) length of time before describing the color. The intensity of coloration may be of aid in delimiting the usefulness of the test.

This preliminary investigation suggests interesting possibilities for separating various species, genera, and families which will be discussed briefly.

In the genus Acer, all the species examined, except box elder (*Acer negundo*) and its varieties, gave an intense color in a short period. This is a color test for separating this species from all the others in the genus. It was noted, however, that the pith of young twigs of box elder, as well as wood which had inner bark attached, gave the purple color. If mature wood is being tested, this is of no consequence. The fact that the wood of box elder gave no purple color, whereas that of the other maples did, may be of significance taxonomically, because box elder is the only species of Acer, at least among the native trees, which has compound leaves.

In the genus Quercus, it appeared that the species in the red oak group, with several exceptions, gave the purple test in both sapwood and heartwood, whereas the species in the white oak group did not give the purple color in the heartwood and only a few species (overcup oak, bur oak, and swamp chestnut oak) gave it in the sapwood. It is impossible at present to separate many species of oak from each other, so that further studies in this genus may prove to be of considerable value for their identification.

The fact that the sapwood of shortleaf pine gave a definite purple color in a short time and the sapwood of loblolly pine did not, points to the possible use of the reagent for separating the common southern yellow pines. The heartwood of longleaf pine or of slash pine did not give a purple test. Unfortunately, authentic sapwood samples of these species and heartwood samples of shortleaf and loblolly pines were not available, so that the series could not be completed. The sapwood of pond pine gave a positive test, whereas that of sand pine did not.

In the genus Picea it was hoped that the eastern spruces might be differentiated, but this was not true. Only Sitka spruce can be definitely separated and this is not necessary for the wood anatomist. On the basis of speed of reaction and intensity of color, certain species of the true firs, Abies, may be identifiable.

It seems likely that black willow can be separated from the aspens and some of the cottonwoods by this means; also, that certain species of the genus Populus may be distinguished in this way. One instance where a variety gave a different reaction than the type species is the case of northern black cottonwood and black cottonwood.

The heartwood of American elm gave a negative test but the heartwood of rock elm gave a faint color. Slippery elm heartwood gave a strong test.

In the genus Carya certain of the species gave a purple coloration, whereas others did not. Thus, for example, the wood of pignut hickor

could be separated from that of shagbark hickory.

All four of the American species of hemlock give a purple color. The species of Juniperus described in Harlow and Harrar (*Textbook of Dendrology*) give a positive test, with the exception of the sapwood of eastern red cedar. The commonly found members of the Betulaceae indigenous to the United States give a purple color, with the exception of gray birch (only sapwood available for this species). The only species of Prunus available for study (pin cherry, black cherry, western choke cherry, and laurel cherry) give a purple coloration in less than 15 minutes.

In those species where the sapwood and heartwood are indistinguishable, it would be possible to separate these portions if one or the other gave the purple test. In some species in which sapwood and heartwood can easily be identified, it has been found that different color reactions occur with the methanol-hydrochloric acid reagent. Overcup oak is one example where the sapwood gave a purple color and the heartwood did not. Perhaps, as Isenberg suggested several years ago, the sapwood and heartwood of white fir are distinguishable by means of a color reaction.

To study the limiting conditions of the tests, 1-gram samples of airdry basswood sawdust were treated with 20 ml. of various solvents and various acids.

The presence of 5 percent or more of water in the methanol decreased the speed and the intensity of the color development. In basswood 25 percent of water in the methanol prevents color development. However, 50 percent of water in the methanol did not prevent a color formation in airdry southern red oak sawdust. In the latter case the color developed much more slowly than in the normal test and was also less blue than in the normal test. In testing samples of green wood, the water in the sample tends to dilute the methanol and may result in false negative tests in certain instances.

Methanol is by far the best solvent investigated for use in the test. Absolute enthanol results in a weak test. The addition of small amounts of methanol to ethanol results in a somewhat stronger test. The other solvents investigated did not give a positive test on basswood.

The concentration of the acid does not appear to be critical; the use of one-tenth the normal amount of acid results in a definite but lighter color; the use of ten times the normal amount of acid results in only a slightly less intense color, probably the result of the addition of the water in the acid. The other acids tested were used in amounts equivalent to about 10 times the normal amount of hydrochloric acid. Sulfuric, hydrobromic, and *p*-toluenesulfonic acids give the test. Trichloroacetic acid gives only a faint test. Phosphoric, oxalic, and dichloroacetic acids do not give a positive test.

It is impossible to say at present what component of the wood is responsible for this color reaction with methanol-hydrochloric acid. Future studies will be directed toward the determination of this component and its location in the cellular structure of the wood, the use of the test in wood identification, and how such wood components may cause color difficulties in the pulp industry.

—*Journal of Forestry*, Vol. 43, No. 12, dated December, 1945.

MANURES AND MANURING *

SUDHIR CHOWDHURY

Chapter VIII

SEA-WEED AND WATER HYACINTH

The use of sea-weed as a manure was already well known to the early Romans as is shown by the writings of Palludins who stated that after washing with fresh water, it can take the place of manure with other substances. Sea-weed has long been used for manurial purposes in the Islands of Thanaet and Jersey in the Hebrides, in Scotland, England, Ireand, Sweden, Japan and elsewhere

Chemical Composition

Most of the earlier analysis of sea-weed were of the ash rather than of the entire plant. Dr. Forchammer made complete analysis of the ashes of many genera and species of sea-weed. Amongst his determinations are the following:

	Fucus digitatus	Fucus vesiculosus	Fucus serratus
Potash	20.66	13.01	3.98
Soda	7.65	9.54	18.67
Magnesia	6.86	6.12	10.29
Lime	10.98	8.36	14.41
Phosphoric acid	2.36	1.16	3.89
Sulphuric acid	12.33	24.06	18.59
Ferric oxide	0.57	0.28	0.30
Silica	1.44	1.15	0.38
Sodium chloride	26.18	21.48	16.56

The following analysis by Wheeler and Hartwell show the composition of several different varieties of sea-weeds following the rinsing off of the salt water and the removal of the superficial moisture:

—	Water	Nitrogen	Phosphoric acid	Potash	Lime	Magnesia.
Laminaria saccharin	88.0	0.17	0.05	0.16	0.38	0.17
L. digitata	87.5	0.23	0.06	0.31	0.41	0.22
Rhodymenia palmata	86.3	0.37	0.09	1.07	0.46	0.09
Ascophyllum (Fucus) nodosum	77.3	0.24	0.08	0.64	0.48	0.35
Fucus vesiculosum	76.6	0.38	0.12	0.65	0.45	0.31
Phyllophora membranifolia	66.2	1.08	0.14	0.96	5.11	0.69
Chondrus crispus	76.0	0.57	0.13	1.02	0.49	0.33
Cladostephus verticillatus	71.2	0.45	0.22	1.42	0.87	0.36
Polyides rotundus	58.5	0.70	0.16	1.45	0.37	0.46
Ahnfeldtia plicata	59.0	1.35	0.25	0.59	0.98	0.29
Zostera marina	81.2	0.35	0.07	0.32	0.51	0.32

*Continued from the *Indian Forester*, Vol. 72, No. 5, dated May, 1946.

Practical Utilization

Sea-weed decomposes readily in the soil and exerts its manurial effects chiefly in the first season. For grasslands it can be used as a top dressing but, as a rule, it is better to apply sea-weeds to lands that are about to be ploughed. In some parts of Rhode Island sea-weed is generally considered preferable to farm manure in so far as concerns its effects upon the smoothness of the potato tubers, but in regard to the cooking qualities of the tubers, unfavourable results from its use have been reported. Studies at the Rhode Island experiment station have shown that the difference in the smoothness of the potato tubers is due to the alkaline effect of the farm manure on the land which creates conditions favourable to the development of potato scab, whereas common salt and other chlorides such as are associated with sea-weed have the opposite tendency.

Concerning the effect of sea-weed on the quality of the potato tuber, it must be borne in mind that if it is not leached before application to the soil, it carries with it common salt. Schult, Salfeld and other German experimenters have shown conclusively that the application of chlorides just before planting the potato crop, results in a depression of the starch content of the tubers, increasing at the same time their nitrogen content and causing the frequent development of a soapy taste.

On account of the adhering sea-water, sea-weed may also be injurious to hops, to the burning quality of tobacco, and many depress the sugar contents of beets. It is recommended, therefore, to allow the sea-weed to be leached by rain before applying it to the land.

Sea-weed compared with Farm Manure

Sea-weed is comparable as a manure with farm manure though slightly deficient in phosphates. In field experiments it has been found that sea-weed gave, with potatoes, quite as good results as an equal weight of farm manure. It has the advantage over farm manure, of being more easily fermented and quite free from the seeds of weeds which are often abundant in the latter product.

Composting Sea-weeds

Sea-weeds are composted to a considerable extent on the coast of Brittany, France, Sweden and other cold countries. They are often piled in layers, each from 6 to 8 inches deep, with a quantity of lime scattered between them. The pile then turned over occasionally, and at the end of from 2 to 3 months, when well-rotted it is ready for use. Sea-weeds are also often composted with farm manure, but whatever the method followed it is a wise plan to keep the pile covered with at least a thin layer of moist soil in order to prevent the possible loss of ammonia.

Sea-weed not a well-balanced Manure

It is well recognised that sea-weed is not a well balanced manure for all soils and crops, and that to supply the needed amount of phosphoric acid in sea-weed, in all cases, would result in a frequent waste of potash or nitrogen or of both. On this account sea-weeds should be supplemented by bone-meal, basic slag meal, acid phosphate or other phosphatic manures.

Water Hyacinth

The analytical figures detailed below indicate that water hyacinth (*Eichornia crassipes*) contains considerable stores of valuable plant food of which potash is the chief constituent. If rotted, the residue contains about the same amounts of nitrogen and phosphoric acid as, perhaps more than, ordinary farm manure and is approximately five times as rich in potash as farmyard manure containing a similar percentage of water.

The composition of water hyacinth and cowdung on a common basis of 65 per cent moisture for comparison is given below:

	Nitrogen	Phosphoric Acid	Potash	Organic matter
Water hyacinth (*Eichornia crassipes*) normal size	0.45	0.32	2.52	27.95
Water hyacinth (*E. crassipes*) large size	0.60	0.23	2.61	72.95
Cowdung (Voelcker)	0.56	0.20	0.50	25.56

Water hyacinth is apparently not as rich in potash as the best marine sources of kelp. For instance, Hendrick gives roughly 28 per cent as the average total ash content of the dry matter of *Laminaria digitata* (stems and fronds). For *Fucus* the average total ash content in the dry matter is about 20 per cent and the corresponding figure for dried hyacinth also approaches 20 per cent. On the other hand, the percentage K_2O content of hyacinth ash (average about 25 per cent) appears to be nearly equal to that of *Laminaria* (26 per cent) and decidedly higher than *Fucus* (15 per cent). Of course, the kelp also contains iodine, which is a valuable constituent, but the respective problems involved in the use of see-weed and of water hyacinth either as organic manures or for the production of ash, are not dissimilar.

The high potash content of these weeds is of considerable importance in North-Eastern India where the soils of the old alluvium are, on account of the leaching effect of the heavy rainfall, generally deficient in lime, potash and phosphoric acid. The results of field tests show conclusively that water hyacinth is a valuable manure either in the rotted state or as ash. On the high, light, well-drained soils the rotted material might be preferable but on heavy low-laying lands the ash would probably be more successful.

It is worth remembering that if the fresh green plant be immediately stacked for rotting, a very serious loss of valuable material takes place in the liquid exuded during the rotting process. To prevent this, either the whole of the plant should be dried for a few days before stacking, or the fresh plant may be stacked in alternate layers with dried plant; a similar result would be obtained by mixing the fresh plant with earth or with dried weeds.

Water hyacinth serves a suitable raw material for composting.

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VOLUME 72 NUMBER 10

INDIAN FORESTER

OCTOBER, 1946

WHAT IS FORESTRY RESEARCH?

By Professor E.P. Stebbing

(Department of Forestry, University of Edinburgh)

Early in March the Principal, University of Edinburgh, received a letter from Mr. W.H. Guillebaud, director of research and education, writing on behalf of Sir Roy Robinson, chairman of the commission, offering, in view of the heavy work thrown on the staff of the forestry departement by the increase in the number of students taking forestry, to consider making a grant to the university of £7,500, spent over the next five years, to enable the teaching staff of the department to be increased. The letter continued "They, (the commissioners) would, however, wish to make it a condition that research or investigations which would further the knowledge of the theory and practice of forestry, should be undertaken by members of the staff of the forestry department."

As a result of this letter, the dean of the faculty of science invited me to visit him, bringing with me my staff.

The chief matter considered was the question of the nature of the forestry research which the commission wished to have undertaken by the strengthened staff. The dean suggested it referred to work in the laboratories—I demurred to this, thinking that so far as the staff of the department were concerned, work in the field was more probable. No concrete opinions were offered as to what was actually meant by forestry research.

As decided at this meeting I subsequently called one of my staff in the department. It was decided that the additional lecturers were desirable—one to confine his lecturing to home and European forestry, and research on such lines as desired by the forestry commission.

It was also suggested that it was necessary to ascertain from the commission exactly what was implied by the remark in their letter "that research and investigations which would further the knowledge of the theory and practice of forestry......"

Shortly after Mr. Gosling, director for Scotland, forestry commission, took me out on a visit to some of the Dumfries forests. On the run out from Edinburgh to Dumfries I asked Gosling what he understood by forestry research, apart from purely laboratory work. He replied that what he wanted was an investigator to carry out a series of experiments with basic slag for different species and on different soils and so forth. This, I said, I would consider to be the work of a purely research officer of the forestry commission, or any other government forest department. It was a rather limited investigation and I did not see how it would apply to the staff of a university who would only be able to carry out the field operations at definite periods in the year.

Later I had talks in London with both Mr. Guillebaud and Sir Roy Robinson.

To Mr. Guillebaud I pointed out that, referring to his letter to the principal of the university, it was not clear to the dean of the faculty of science, or to my department, what was meant by the research work involved. Guillebaud said he did not think the chairman wished to lay down any specific rules or directions in this matter, but would leave it to the decision of the head of the university forestry department concerned. That this was meant when he had written in the letter "They would, however, wish to make it a condition that research or investigations which would further the knowledge of the theory and practice of forestry would be undertaken by members of the staff of the forestry department." He continued that they would not propose to lay down any specific work in this respect for the new lecturers, but rather that they wished the whole staff of the department to undertake research work, being now in a position to do so with the lightening of lecturing burdens.

In my interview subsequently with Sir Roy Robinson, after I had mentioned

my remarks to Guillebaud about forestry research, and what was meant by the words in the letter to the principal, Sir Roy was even more emphatic. He said he did not wish to hold the university to any stipulated course in this matter. That he had no desire to lay down any rules or lines of research. All he wanted was an undertaking that with an increased strength in the staff, all the members should take up some line of research which would be beneficial to forestry. Sir Roy added, as an illustration of his meaning, that it would be most useful to undertake research surveys and investigations into the past history of a selected region in which the commission were operating, with the object of ascertaining what forests, if any, had previously existed in the area, existing soils and flora and changes which had occurred in these—changes in habits and numbers of the population, and so forth.

At the end of these meetings and talks it became evident that no one had laid down any definition of what was actually meant by forestry research, outside the purely laboratory work which some branches of forestry, if not all, might demand; and the work of the commission's own research officers.

What is forestry research? Is there a definition? Work in the laboratory has been accepted and excluded from the present consideration.

The next type is research undertaken in the field by the research officer who is also a trained forest officer. This is equally clear cut. He is set, or is occupied on his own account, with a special problem arising out of troubles or difficulties encountered by the working (executive) forest officer encountered in the course of his operations. Or he may be working on a line tending to improve a certain operation or operations in connection with one or more of these which may render their introduction more effective. Or with a method or methods which may entirely change those so far in force.

Here again, the work of the research officer in the different branches of forestry science is well understood by the ordinary executive forest officer.

But these two do not answer the question under consideration.

What is understood by forestry research by the average forest officer or member of a university forestry staff, neither of whom come under the two categories above mentioned!

The forest department in India was formed in 1864. The forest research institute at Dehra Dun was inaugurated in 1906. For the first 25 years after its formation, the Indian forest department was fully occupied with forest reservation, introducing forest protection, including fire protection, and improving methods of exploitation, introduction of forest working plans and so forth. By the end of this period a few of the executive officers had made the first attempted studies of the sylviculture of a few of the more commercially important species. These separate papers had been published, if accepted, by the government of India as appendices to the *Indian Forester* (the latter being a private departmental journal). These papers may be accepted as one of the first important steps, small and tentative as they were, taken in the realm of forestry research in India, and were undertaken by the executive officer apart from his ordinary duties, and may be regarded as an example of true research in a branch of forestry of which little was previously known.

Is there a possible analogy in this country? Well, what do we know (or do we) about the sylviculture of birch, of which well grown timber of suitable size has proved in demand during the recent war!

Another Indian example is connected with the problem known as the erosion of the outer Punjab hills. These are the lower Himalayan slopes covered with *Pinus longifolia* forest. This is a long standing matter, dating back to the latter part of last century. For political reasons, the government were unwilling to interfere with the habits of the local population —unchecked grazing of goats and other stock, hacking and lopping the trees and more or less unchecked firing of the areas. With the completion of the big canal irrigation schemes which turned so much of the Punjab plain into rich, crop-producing areas, the irrigation engineers soon discovered that this erosion in the hills was imperilling, through silt, the headworks of their canal system. The warnings of the forest officers, successive generations of them, had passed unheard. Government now began to listen. The engineer spoke in terms of expensive preventive works in concrete, and so forth. The local forest officers, conservators and district officers

who had successively had charge of and studied the region, had by small local experiments convinced themselves that mere closure of an eroded area would result in the reclothing by forest. Examples now exist where an area closed against man and all his works and stock, and against fire, has become completely restocked with a tree growth, and erosion checked whilst at no great distance, on a similar hillside, erosion has reached a stage almost beyond man's power of restoration.

Similarly, in that old continent, Africa, where serious desiccation and aridity and failing water supplies are becoming increasingly serious, the executive forest officer of recent years has been undertaking investigations outside his ordinary duties, with the object of endeavouring to supply indisputable proof that the unchecked agricultural practices of the population, by what is known as 'shifting cultivation', and the unchecked grazing of increasing herds of stock, coupled with the annual firing of the countryside, customs and practices with which the government were unwilling to interfere, is a cause leading up to aridity, desiccation and failing water supplies. With their soil reclamation committees in various parts of the British Empire, based on the lead given by the United States, government have at last become awake to the possible position. But the pioneer work of the forest officer can well come under the interpretation of forestry research.

Another instance may be cited. After the 1914-18 war the French forest department took up the question of afforestation in the heather, etc. covered hill and mountain areas in various regions in France. One instance was in the Auvergne (highest point about 6,000 feet.) Here, large areas of heather-clad hills were in the ownership of the various villages. Some work of this kind had been attempted with Scots pine by both government and private proprietors in the seventies of last century. The country people objected to their grazing grounds being taken away in this fashion, shot two or three forest guards and the project came to an end. Some excellent plantations were, however, the result, and their value was demonstrated when the enormous demands for soft woods by the armies became apparent.

When this project was again under review in the early twenties of the present century, at the instigation of the director general of forests in Paris, an experienced senior officer was despatched to make a study of the countryside, to ascertain informally the ideas and opinions of the villagers on the subject of crops, stock and the summer grazing in the higher pasturages, cheese making on the spot being the summer occupation of the cattle owners. The officer studied the nature of the terrain, aspects, soils, their covering and so forth. Considerable information on these matters was obtained from the proprietors of the private estates in the region, who were the fortunate owners of some of the plantations commenced in the seventies, of which careful records had been kept. In connection with this type of investigation required as a preliminary, it will be remembered that France, with some well known exceptions, were not accustomed to afforestation work; their main forest being naturally regenerated. Moreover, silver fir was the chief marketable species of this region—a species useless for afforesting bare ground. I have only summarised very briefly the interesting report submitted by the officer. As a result, the department took the next step towards reintroducing this afforestation work—a step even more delicate, since the village consent had to be obtained in every case; but this does not come within the purview of my present problem. More important, as a result of the investigations of this officer, it was realised that the afforestation work when started, should be by direct sowing of the pine seed, which in this event proved highly successful in many cases. Would not this type of operation and investigation of the forest officer, or executive officer, come under the head of forestry research?

A parallel example, but of a different type, may be drawn from the work of the forestry commission during the past 25 years. A member of a university staff is asked to devote his research work to home forestry. What must be his first step? To select a region within which he proposes to confine his investigations. What is to be his next step? Any scientifically minded man starting on a piece of research work with *e.g.*, the idea of arriving at and obtaining a D.Sc. degree which entails original work, will find that his first step will involve his making himself acquainted with all the research work which has already been done in the subject. This is the point of departure. He can then begin to assimilate the

additional data and knowledge he has acquired, and assign to their correct position the items of new knowledge he possesses and assess the advance he has made in the subject for which he intends to present a thesis for the degree.

Our university lecturer, in the same way, would first have to carefully study all the stages by which the work of the forestry commission had progressed before he could proceed further. But ere he arrived at this point, his study might have led him insensibly, whilst engaged on this work, to record notes which, of themselves, might prove of use to officers of the commission in the region concerned. Is this not forestry research?

Take an example from the forest of Dean. Part of the Cockshoot Inclosure, the part not clear felled, has been under natural regeneration operation for some years. I have used it, interchanging with Nagshead, as the regeneration periodic block for the working plan made du ing their final practical course by the Edinburgh forestry students. An interesting study has been possible of the type of wide and low branched old oak in this and other areas and the effects of the type on the regeneration when it has appeared on the forest floor. It would appear from this study that the commonly accepted text rules on the methods of making seeding, 1st and 2nd secondary fellings have to be considerably departed from if success is to be attained both in securing the regeneration and in preventing the possible checks in the progress of repressed growth.

This, in my opinion, is a type of forestry research which can be best undertaken by the executive officer in charge of the area.

Two other instances both from Thetford. The experimental work carried out in the early thinning of the first young crops to reach a possible age to start this work. This age and the work introduced broke all records known to me in temperate regions of what appeared a precocious growth. This, however, did not lessen the high interest in the work undertaken, and its results so far apparent. Somebody had to make the start, but the experimental work was research.

. . . .

A smaller instance—The case of the young plantation of Scots pine and oak, where the oak was held in check. Various possible reasons, as is usual on the countryside for unforeseen checks in many other branches of activities besides forestry, were voiced including suggested laboratory investigations. The officer on the spot at length suggested and undertook the lagging up of the pine. With this operation performed the oak commenced to go away. Research! Well I do not know—What would it be called ?

. . . .

I have refrained from discussing such problems as working plans, the periodical measurements, and g neral maintenance of sample plots, as these operations come naturally within the province of a forest department's research officer. A university forestry staff might well, if asked, be able undertake certain pieces of work in this connection.

. . . .

Has this note been able to furnish, in some degree, an answer to the question put at the start. What is forestry research?

THE GHAGGAR RIVER CATCHMENT AREA*

BY MOHAMMAD SAID, M.Sc., A.I.F.C., P.F.S.(I),

(*Divisional forest officer, Ambala soil conservation division*).

I. Introduction

The Ghaggar river is crossed at the 21st mile from Ambala on the Ambala-Kalka road. It originates from Simla district, Ambala district and the Simla hill states, and after flowing through the plains of Ambala district, Patiala state and Kalsia state gets absorbed in the fields of Hissar district. During its course many hill torrents, such as the Dangri, join it.

The submontane tract of Ambala district contributes considerably to the water content of the river, when rain water falling on deeply cut ravines brings a lot of silt and sand with it and is responsible to some extent for peak floods in the river (*see Appendix I*). Above the crossing of the river on the Ambala-Kalka road can be taken as the catchment area. This is about 278 square miles (as measured by a planimeter on the map). The main torrents lying in this area and which combine to form the river are as below:—

NAME.	Area of the catchment in square miles.	Administrations in which the catchment area lies.
Koshalya and Jhajra ..	52·17	Patiala state, Baghat State, Kalka, Sanawar and Dagshai.
Ghaggar branch I ..	57·12	Patiala state, Sirmoor state, Morni (Ambala district).
,, ,, II ..	65·40	Sirmoor state, Patiala state and Morni (Ambala district).
Sukhna Cho ..	57·97	Ambala district, Kalsia state and Patiala state.
Medkhali Cho ..	45·55	do.
Total	.. 278·21 square miles=177,920 acres.	

The area of 278 sq. miles is distributed in the various administrations as below:—

ADMINISTRATION	Undulating plain	Hills	Total
Patiala state	33·50	70·70	04·20
Sirmoor state	..	39·24	39·24
Baghat state	..	10·48	10·48
Morni hill tract (Ambala district)	..	32·88	32·88
Naraingarh Tahsil (Ramgarh area) Ambala district	25·76	7·92	33·68
Kharar Tahsil (Ambala district)	33·71	11·06	44 77
Kalsia state	11·01	..	11·01
Dagshai and Sanawar, Simla district	..	1·08	1·08
Kalka (Ambala district)	·87	..	·87
Total ..	104·85	173·36	278·21

From the above total it will be seen that only 2/3rds of the catchment area is in the hills and thus the sloping plains contribute a great deal to he peak floods. The whole of this plain area is sloping and is suffering from sheet erosion and at many places also deep ravines have been formed.

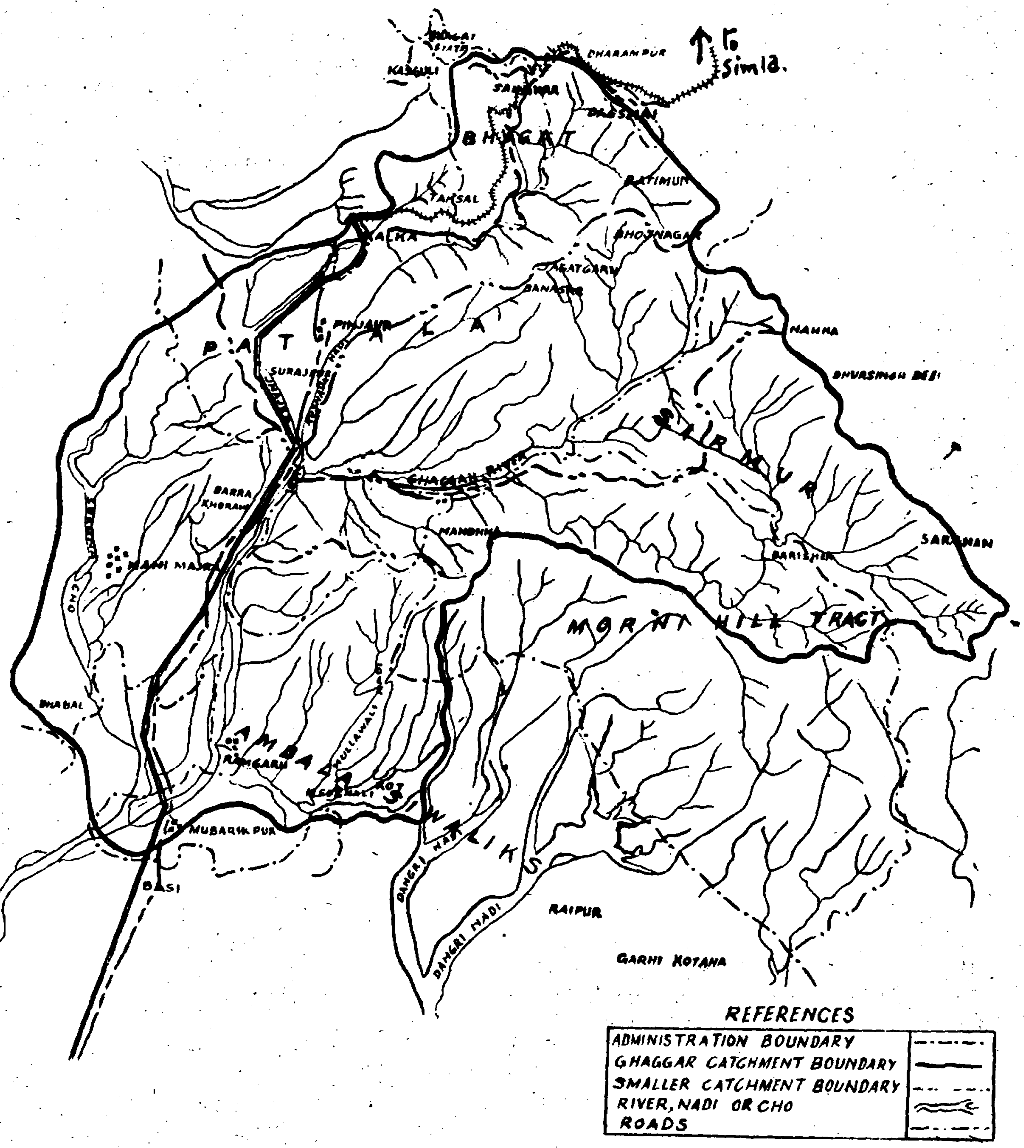
The rainfall in the catchment area varies from 35 to 45 inches. In the upper reaches of Koshalya, Ghaggar I and II, snow falls in winter which melts away after a few days. The highest point in the catchment area is Bhursinghi Debi in Sirmoor state, 6,224 ft. high.

II. The Catchment Area

The catchment area can be divided into four parts (*vide map on page* 454).

*Paper presented at the Soil Conservation Circle Officers Conference, Punjab, held at Hoshiarpur on 19th to 21st November, 1945.

GHAGGAR RIVER
CATCHMENT AREA
SCALE 1 INCH = 4 MILES



1. *Sloping land facing Ambala plains.* Ramgarh and Sukhna *cho* areas. This region is full of ravines and *cho* beds, and sheet and gully erosion are prevalent. The area is mostly under cultivation but the standard of cultivation is extremely poor. The fields are sloping with the result that rain washes down the top soil and thereby decreases the fertility of the soil.

2. *The Siwalik ridge.* The Siwaliks portion lying in the Ghaggar catchment area forms the *shamilat* (common land) of various villages lying in the foothills. The hill consists of a soft earthy formation with friable sandrock. Erosion has gone far and ravines and broken land are frequent. It is practically without vegetation. Grass is scanty and is of poor quality. A few *kikar* (*Acacia arabica*) *phulai*, (*Acacia modesta*), *Diospyros*, *Flacourtia* are all that are left. *Bhabbar* grass is available in good quantities in some parts of the area too steep for heavy grazing.

3. *Kalka Doon between Siwaliks and Dagshai & Sanawar ridge.* This has a varying width of sloping land. It should have been very fertile but misuse in the past led to gullies and ravines which are now frequent.

4. *Dagshai-Sanawar ridge.* The underlying rock is sandstone but shale and schist are also found. Slopes are steep and slips occur occasionally. Due to proximity to the town of Kalka and thus easily approachable by a road, the cutting of valuable species has been indiscriminate and grazing has been uncontrolled. There are a few patches in Patiala where there has been strict control for *shikar* and which are well covered with vegetation.

III. Types of Forests in the Catchment

The hills support the following different kinds of vegetation:—

1. *Chil* (*Pinus longifolia*) forests occur in Patiala, Sirmoor, Baghat and Morni in the upper reaches only. They are mostly protective forests. The quality is low and the growth has suffered much on account of fires made by the inhabitants to get fresh grass.

2. *Bamboo* occurs in Sirmoor, Patiala and Baghat. The quality of bamboo on the whole is poor. Unsystematic working has resulted in the deterioration of the clumps.

3. *Scrub.* The rest of the area is all scrub of varying density. The Siwalik ridge supports a very poor type of open scrub. Only a few trees are seen here and there and the hillsides are practically devoid of vegetation. *Thohar* (*Euphorbia royleana*) is found over large areas in the Dagshai-Sanawar ridge. It appears that it is due to indiscriminate *Gaddis'* sheep and goats grazing in the forest. *Gaddi* grazing has been stopped wholly in Patiala and parts of Sirmoor state and Morni hills. Baghat state still admits them. They do a lot of damage while passing through Sirmoor state annually.

IV. Grazing Incidence and Cultivation

Grazing incidence and cultivation is discussed for various administrative units separately in detail as below (*Also see Appendix II on* page 459):—

1. *Medkhali* (*Ramgarh*) *catchment area.* *General.*—The total area of this portion is 22,162 acres which is made up of 5,639 acres of hill and 16,523 acres of slightly sloping plain. Out of the latter 10,124 acres are under cultivation and the rest 6,399 acres are uncultivated under *cho* bed or ravines. Thus the cultivated area is 61 per cent of the total plain area and uncultivated 39 per cent.

Closed area.—The whole of the hill area together with the cultivation is closed to browsers. 2,981 acres are closed under section 5 of the *chos* act to all animals and are under the control of forest department and in another 1,514 acres the closure has been enforced by the owner. Thus 4,495 acres of the hill *i.e.* 80 per cent of the total hill is closed to all grazing. The remaining 20 per cent is left for grazing. The section 4 line comes right to the toe of the hill and whole of the area within it, including cultivation, is closed to browsers.

Closure in the plain.—At present there is no notified closure in the plains. There is a co-operative soil reclamation society at one place only. Applications under section 38 Indian forest act have been obtained for a number of villages and the papers are under preparation.

Grazing incidence. Taking one cow as equal to 2 sheep and one camel as equal to 4 cattle, the grazing area per head comes to 0·9 acres. If all the browsers are eliminated and the cattle are the only grazing animals left, then the grazing area per head of cattle comes to 1·1 acres. The incidence of grazing in both the cases is very high.

2. *Sukhna cho catchment area in Kharar tahsil.*

General.—The total area of this portion is 29,745 acres out of which 5,846 acres are hill common and 288 acres are under cultivation in the hill and 23,611 acres are in the plain. Out of the plain portion 7,358 acres are uncultivated common and 16,253 are under cultivation. Thus the percentage of cultivation to the total area in the plains is 69 per cent.

Closed area.—The whole of the hill 5,846 acres together with included cultivation of about 288 acres *i.e.* total of 6,134 acres are closed under section 4 of the *chos act*. An area of 2,081 acres is closed under section 5 which is about 35 per cent of the total hill area. The villagers residing at the foot of these hills area *Gujjars* and large areas had to be left open to meet their grazing requirements. Efforts to close more voluntarily are meeting with some success. In the plains portions there is no closed area.

Grazing incidence.—The grazing area per cattle taking the equivalent cattle for browsers in this tract comes to about 0·6 acres which is extremely low. Without browsers the area is 0·7 acres which is also very small.

Afforestation work in hill portions of Medkhali and Sukhna cho catchment areas.—Efforts are being made to reclothe these bare hills with vegetation again and to stop erosion. *Bhabbar* (*Ischoemum angustifolium*) planting is being done extensively in these areas, also sowing of suitable species on trenches. *Shisham* (*Dalbergia sissoo*) planting is done in the *khols* (*nala* bottoms).

3. *Kalsia state area.*—There is a small portion of Kalsia state which forms a part of the catchment area of *chos* coming from Kharar tahsil and Ramgarh area. The total area is 7,820 acres which comprises 4,043 acres of cultivated land, 3,709 acres of uncultivated land and 68 acres of state *bir* (savannah type forest closure). The cultivation is thus 52 per cent of the total area.

Grazing incidence.—The area available per head of cattle including browsers (converted into equivalent cattle) is 1·1 acres and without browsers comes to 1·3 acres. In both the cases the area is very small.

4. *Morni hill tract.*—The total area of this tract forming the catchment area of the Ghaggar river is 19,985 acres, out of which 3,140 acres are under cultivation and the rest are all forests in which the people have rights of grazing and cutting of trees for their domestic use. From 1st April 1943, the forests have been taken over by the forest department on a long lease of 25 years and are now under a proper working plan.

The rights have been regulated by notification under section 4 of the *chos* act under which all browsers have been eliminated and the people can cut trees for their domestic use only with the permission of the divisional forest officer. Lopping of seven species *viz.* *Chil*, *Jhingan* (*Lannea grandis*), *Chal* (*Anogeissus latifolia*), *Sain* (*Terminalia tomentosa*), *Khair* (*Acacia catechu*), *Simal* (*Bombax malabaricum*) and bamboo has been stopped.

The total area in the Ghaggar catchment is 19,985 out of which cultivation is 3,140 acres and forests are 16,845 acres.

The cultivation is thus about 16 per cent of the total area. About 1,200 acres out of the forests are under *chil* and the rest is all scrub of varying density and quality.

Grazing incidence.—The grazing area per head of cattle in this tract comes to 4 acres.

The incidence is not very heavy but at places slips have been formed which require immediate closure. The destructive habits of the population are fast destroying the forests. It is proposed to close more under section 5 to fill up the blanks and stop further erosion and slips.

5. *Sirmoor state.*

General.—This state forms part of the catchment areas of two main branches named Ghaggar I and II. The area is all hilly, the maximum height going up to about 6,200 ft. The total area of this portion of the catchment is 25,269 acres out of which 2,823 acres are under cultivation and the rest 22,446 acres are all waste land. The cultivation is thus about 11 per cent. of the total area. Out of the total waste an area of 7,755 acres are under the control of the forest department and the rest 14,691 acres are village grazing ground (*charand*) where the villagers can do whatever they like. There is no working plan for this.

Grazing incidence.—Grazing area per head of cattle inclusive of browsers, converted into equivalent cattle, comes to 2·4 acres and without browsers 3 acres. Besides sheep and goats of the villages, some *Gaddi* flocks are also introduced in some parts by some local *jagirdars*, the exact number of which is not known. This increases the pressure on the ground even more.

Forests.—There are *chil*, scrub and bamboo forests in this region. Fires occur every year in the *chil* forests. They are started by villagers to get fresh grass. The *chil* areas have deteriorated

considerably. The people can get timber from village grazing grounds with the permission of the collector. From the state forests the villagers can get timber by paying some nominal fee. Grazing is also allowed, free in the case of villages which have no village forests of their own, and on the payment of some nominal fee for others.

6. *Bhagat State.*—An area of 7,425 acres of this state forms the part of catchment area of Koshalaya branch of the Ghaggar river, which is distributed as below:—

Cultivation	..	796 acres, *i.e.*, about 10 per cent. of the total area.
Uncultivated *shamilat*	..	3,162 acres.
Village grazing ground	..	900 „
State control forests under a working plan	..	2,603 „

All the state forests are open to grazing. Out of these 1,450 acres are under *chil*, the remaining 1,153 acres are under scrub and bamboo. Most of the forests get burnt by sparks from the engines of Kalka-Simla railway. They are worked under an improvement felling system. From the grazing ground the people cannot cut trees except with the permission of the forest department but in the cultivated common land they do whatever they like.

Grazing incidence.—In this region about 1,500 *gaddis'* goats and sheep are admitted for about 5 months besides the villagers' cattle, sheep and goats. Taking 2 browsers equal to one cattle (4 *gaddi* browsers taken as equal to one cattle as they remain for a short period) the grazing available per head of cattle comes to about 1.7 acres.

If all the sheep and goats are eliminated, then incidence on account of cattle alone comes to about 3 acres per head which may be said as just sufficient for this kind of tract.

7. *Patiala States.*—

Patiala state forms part of the catchment area of three main torrents, *viz.*, Koshalaya, Ghaggar and Jhajra. The total catchment area of Koshalaya lies in Baghat and Patiala territories and while that of Ghaggar lies in Patiala, Sirmoor and part of Morni. The catchment of Jhajra is very small and is wholly in Patiala state.

The total area of the catchment in Patiala state is 104.20 sq. miles out of which 3.35 sq. miles are in plain or slightly sloping *doon* and the rest 70.70 sq. miles lie in hills. Out of this big area of 104·20 sq. miles (66,688 acres) only about 26,000 acres are under the control of the state forest department and are under a regular working plan. 16,000 acres are classed as I class forests and 10,000 acres are classed as II class forests.

Out of 16,000 acres of I class forests, 5,000 acres and all II class forests are open to grazing of cattle of the right holders. Felling for domestic purposes for right holders are controlled by the forests department.

Nature of forests.—Out of 26,000 acres of state controlled forests 5,000 acres are under *chil*, 18,500 acres are under scrub and 25,000 under bamboo. Beside the forest 4,068 acres consists of village cultivation and village *charand* in which people cannot cut trees for their domestic use without the permission of the forest department. Grazing is unrestricted. Village sheep and goats are allowed. Uncontrolled grazing and lopping and cutting is degrading the village forests and the people have to depend more and more on state controlled areas for their needs. Cultivation and cattle census figures could not be got for this tract.

V. Cultivation

Cultivation is extremely poor both in the hills and plains. The fields are sloping and no effort is made to retain rain water by terracing the fields and making *wáts*. The result of the sloping fields is that the top soil along with the manure is washed away every time it rains and the fields are being rendered infertile. In the plains the cultivation is hardly more than 69 per cent. of the total available area; in some places it is about 50 per cent. The uncultivated area is full of deep ravines and gullies which are responsible for peak floods, and silt and sand carried by water. There is no vegetation to check the flow of water.

VI. Village Forests

The total uncultivated area in the plain portion is as below:—

In Ramgarh area	..	6,399 acres.
In Sukhna *cho*	..	7,358 „
In Kalsia state	..	3,709 „
Total	..	17,466 „

Out of this vast area one quarter, *i.e.*, about 4,000 acres can be easily closed and planted up with suitable tree species like *shisham* and *kikar*; the remaining three-fourths can be left out for grazing and water courses. Thus one quarter can form village forests and can provide the

villagers with timber for their domestic requirements.

In the hills large areas lie as village grazing ground (*charand*) or village common (*shamilat*) in every administrative unit. They are not under any management, nor is there any control on these areas. The villagers can do whatever they like. The result is that hillsides are becoming bare and erosion is spreading. These areas require regular management on the lines of village forest societies of Kangra district, so that open areas are reclothed with vegetation and the areas bearing tree growth are worked systematically.

VII. Live-Stock in the Catchment Area

From the discussion of grazing incidence in the various administrative units it will be seen that the number of cattle and sheep and goats is extremely large and no grazing ground can support such a high incidence without deteriorating. The only remedy is to reduce the number of cattle and this is not an easy problem. Intensive propaganda should be done to teach the public the benefits of stall feeding and keeping better quality animals.

The browsers do a lot of damage. Incidence of grazing has also been calculated without browsers. But it may be seen that it will be impossible or rather it will be unjustified to evict out all sheep and goats from such a big tract of 278 square miles where the people are accustomed to this grazing from time immemorial and livelihood of many depends upon this. A goat does more damage than a sheep and if goats are evicted even by legislation, and in their place people are asked to keep sheep even then the situation will improve to some extent.

VIII. Object

The ultimate object is to check the flow of water and reduce the peak floods and stop the carriage of silt and sand. This can be achieved by:—

1. Reclothing the area with vegetation so as to check the erosion. This can be best done by closure of as much area as possible and then sowing and planting suitable tree and grass species. The Siwalik hills require urgent closure as the geological formation is very friable and liable to erode very easily. At present 35 per cent. of the Siwaliks in Kharar tahsil are closed under section 5 and 80 per cent. in Naraingarh tahsil. The former requires more closure; the closed area should be at least 66 per cent. of the total hill area. The people living near the hill are *Gujjars* who are in the habit of keeping a large number of cattle, sheep and goats; most of them do not give any milk at all but increase undue pressure on the pasture. They are poor cultivators and do not take trouble to improve the standard of their cultivation.

2. Gully plugging and check damming the ravines so that the flow is reduced to a minimum and sowing suitable shrubs and grass on the silted areas. Although this is a rather expensive method, it is very effective.

3. Proper terracing and *watbandi* of the cultivation. The surplus water should be drained off by *pakka* weirs. The work of levelling of fields will be very easy by mechanised equipment *viz.*, bulldozers and terracers.

4. Wherever forests exist they should be managed strictly on silvicultural principles and the exploitation should be conservative. There is a large area in Patiala, Sirmoor and Bhagat states under forests requiring conservation.

IX. Catchment Area Plans

This area of the Ghaggar catchment requires to be managed under sound soil conservation principles. This will not only reduce the peak floods and sand and silt in the Ghaggar but also raise the standard of cultivation. For this purpose catchment area plans should be drawn up separately for the various torrents forming the Ghaggar river. Each plan will provide for closures, sowing and planting, terracing and *watting* of fields and proper management of existing forests. The catchment areas of the Medkhali (Ramgarh) and Sukhna Chos contain very small areas of states and so there will be no difficulty in enforcing closure and work can be taken up at once.

The following appendix gives the highest flood level in a year measured at Mubarikpur for the last ten years.

APPENDIX I

Year			Highest flood level in a year in ft.		Date
1936	..	..	9	..	21-6-1936
1937	..	..	12·5	..	16-9-1937
1938	..	..	9	..	11-8-1938
1939	..	..	7·5	..	8-8-1939
1940	..	..	11	..	22-7-1940
1941	..	..	11·3	..	17-8-1941
1942	..	..	13	..	6-8-1942
1943	..	..	8	..	10-7-1943 5-8-1943 14-8-1943
1944	..	..	7·5	..	30-8-1944
1945	..	..	10	..	13-9-1945 25-9-1945

APPENDIX II

The following table gives the number of cattle, sheep and goats, camels and grazing area in the various units.

UNIT	Area in acres available for grazing		Cattle	Sheep and goats	Camels	Equivalent cattle one cattle=2 sheep or goats 1 camel=4 cattle	Area per head of cattle $\frac{\text{Col. 2}}{\text{Col. 6}}$	Area per head of cattle if browers are eliminated $\frac{\text{Col. 2}}{\text{Col. 3}}$
1	2		3	4	5	6	7	8
1. Medkhali catchment area	Uncultivated plain area ..	6,399						
	Hill area open to grazing ..	1,144	7,038	3,254	34	8,811	·9	1·1
	Total ..	7,543						
2. Sukhna Cho catchment area	Uncultivated plain area ..	7,358						
	Hill area open to grazing ..	3,765	15,662	3,807	11	17,609	·6	·7
	Total ..	11,123						
3. Kalsia State ..	Uncultivated area	3,709	2,983	797	..	3,381	1·1	1·3
4. Morni Hill tract	Grazing ground	16,845						
	Less closed area	380						
	Net area ..	16,465	4,451	..	..	4,451	·4	4
5. Sirmoor State ..	Available grazing area inclusive of State Forests ..	22,446	7,971	1,267	..	9,238	2·4	3
6. Baghat State ..	Available grazing area inclusive of State Forests	6,629	2,390	2,373 +1,500 Gaddis'	..	3,951	1·7	3

CONSTANTS CONNECTING TOP HEIGHTS AND AGE FOR DIFFERENT SITE QUALITIES IN TEAK PLANTATIONS

By M. S. Raghavan.

(*Silviculturist, Madras*).

A study of the curves in the *Indian Forest Record*, New Series, Silviculture, Vol. IV-A, No. 1—Yield and Stand Tables for Teak Plantations in India and Burma, by Laurie and Bakshi Sant Ram, of top heights by site quality and age, indicates that there is a logarithmic connection between them. Working out the regression co-efficients, in my recuperation leave periods and in occasional spare time, I found that

Log Height = a + b log Age

The constant **a** depends on the site quality. The constant **b** is independent of site quality. In early computations, I found variations not only in the values of **a** but also in the values of **b** for the different quality classes. But while the value of **a** showed a regular trend in variation, the variation of **b** was irregular and slight. The indication was therefore obtained that **b** is a constant, and its value was taken as the mean of all readings obtained for it, *i.e.* 0.3224. After taking this mean value of **b** the values of **a** were recalculated and entered in the appended table on page 46.

For ages 5 and 10, the computed heights by my formula differ considerably from the heights entered in the yield tables mentioned. The probable reason for this is that trees of and below the age of 10 have not yet settled down to their quality classes. This is in keeping also with regression equations which rarely pass through the origin.

For ages 15 to 80, the heights determined by the formula agree very closely with the heights tabulated in the yield tables. The variation is never more than one foot, and in most cases there is agreement. This striking agreement justifies the formula. The small differences noticed may be attributed to the yield tables having been read to the nearest foot from graphs, and to my rounding off to the nearest foot the heights which I computed to 2 places of decimal for accuracy.

The values of **a** for the different quality classes when plotted appear to form the right arm of a parabolic curve. Two types of formulae may connect the values of **a** with the quality classes. I am investigating these in my spare moments. The major crop number of stems after thinning, plotted against age, are hyperbolic in form and are also represented by two types of formulae. These are also being worked out.

Meantime as the results already obtained are probably of general interest, and may be calculated for other species, and as to my knowledge such a connection between the heights of trees and their ages has not been determined anywhere else, I submit this preliminary data.

TABLE

A.I.Q.	I Top		I Mean		II Top		II Mean		III Top		III Mean		IV Top		IV Mean		V Top		V Mean		V Low	
"a"	1·5660		1·5339		1·5021		1·4659		1·4257		1·3863		1·3405		1·2894		1·2314		1·1645		1·0853	
"b"	0·3224		0·3224		0·3224		0·3224		0·3224		0·3224		0·3224		0·3224		0·3224		0·3224		0·3224	
									HEIGHTS													
Age	F	Y	F	Y	F	Y	F	Y	F	Y	F	Y	F	Y	F	Y	F	Y	F	Y	F	Y
5	62	52	57	47	53	43	49	40	45	37	41	33	37	30	33	27	29	23	25	20	20	17
10	77	73	72	68	67	63	61	58	56	53	51	49	46	44	41	39	36	34	31	29	26	24
15	88	87	82	80	76	75	70	69	64	64	58	58	52	52	47	46	41	40	35	35	29	29
20	97	96	90	90	83	83	77	77	70	70	64	64	58	58	51	51	45	45	38	38	32	32
25	104	104	97	97	90	90	83	83	75	76	69	69	62	62	55	55	48	48	41	42	34	35
30	110	110	102	103	95	96	88	88	80	81	73	73	66	66	58	59	51	51	44	44	36	37
35	116	116	108	108	100	101	92	93	84	85	77	77	69	70	61	62	54	54	46	46	38	39
40	121	121	112	113	104	105	96	97	88	89	80	81	72	73	64	64	56	56	48	48	40	40
45	126	126	117	118	108	109	100	101	91	92	83	84	75	75	66	67	58	58	50	50	42	42
50	130	130	121	121	112	113	103	104	94	95	86	87	77	78	69	69	60	60	52	52	43	43
55	134	134	125	125	116	116	106	107	97	98	89	89	80	80	71	71	62	62	53	53	44	45
60	138	137	128	128	119	119	109	110	100	101	91	91	82	82	73	73	64	64	55	55	46	46
65	142	141	131	131	122	122	112	112	102	103	94	94	84	85	75	75	65	66	56	56	47	47
70	145	144	135	134	125	125	115	115	105	106	96	96	86	86	77	77	67	67	57	58	48	48
75	148	147	138	137	128	128	118	118	107	108	98	98	88	88	78	78	69	69	59	59	49	49
80	151	150	141	140	131	130	120	120	110	110	100	100	90	90	80	80	70	70	60	60	50	50

A.I.Q.=All India quality class. Under heights column F given heights calculated by the formula log height=a+b log age. Column Y gives corresponding heights as tabulated in the Yield and Stand Tables by Laurie and Sant Ram.

A NEW HYPSOMETER

By S.D.N.Tiwari, M.Sc.
(C.P. Student, Indian Forest College, Dehra Dun)

Part A

1. *Construction and description of the instrument.*—The construction of this instrument is based on the geometry of similar triangles. It consists of a main strip AB of a metal plate or a wooden piece, 8 units x $\frac{3}{4}$ unit, (inch has been taken as the unit in the actual construction) with B as the drawn out end in line with the axis of the strip. Another strip triangular in shape DEF′ (*vide Fig.* 1), 13 units x $\frac{3}{4}$ unit (basal width) in size is pivoted at E on the axis AB at 5 units from A and at 10 units from D in such a way that it has got a free movement in the vertical plane. Its end F′ is weighted so that the indicator DEF′ points in a vertical direction when allowed a free movement in the vertical plane. G is a sighting pin fixed at right angle on the axis AB at A. A pointing pin is fixed at B in a similar way. The indicator DE is divided in four equal parts of 2.5 units each and at every point a sighting pin is fixed horizontally with its upper edge flush with the graduation mark.

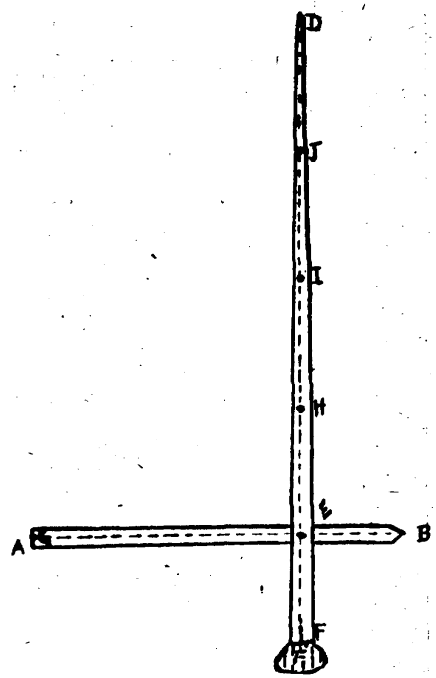


Fig. 1

2. *Use of the Instrument.*—For measuring the height of any tree the axis AEB is directed towards the base of the stem (*vide Fig.* 2) at a man's height on the stem from the ground level. The observer then moves backwards and forwards till A, D, and the top of the tree, are in a straight line. The distance from the measurer to the tree is then measured. Double this distance plus the observer's height to eye level will give the height of the tree.

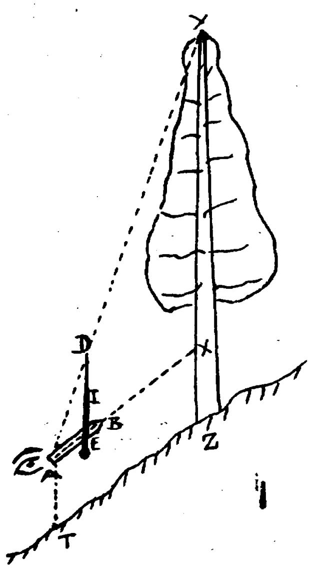


Fig. 2

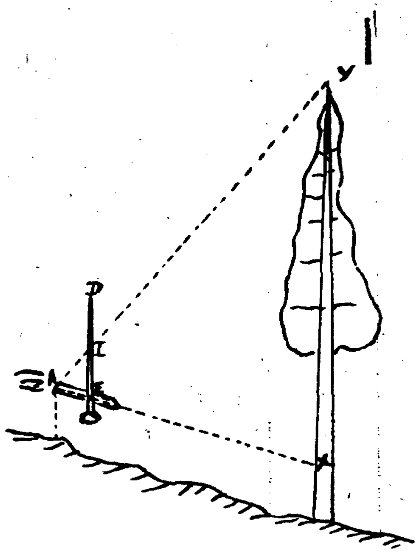


Fig. 3

3. *Principle of Working and Proof.*—In Fig. 2, the axis of the tree and the indicator DE are parallel as both are vertical.

$\therefore$ $\triangle$s AED and AXY are similar

and $\therefore$ DE : AE = XY : AX,

$$\text{or } XY = \frac{DE}{AE} \times AX.$$

$$\text{But } \frac{DE}{AE} = \frac{\text{Height of the indiactor}}{\text{Distance between A and pivot E}} = \frac{10}{5} = 2$$

$\therefore$ XY = 2AX....................(*i*)

In Fig. 2, AXZT is a parallelogram,

$\therefore$ TZ = AX....................(*ii*)

Combining (*i*) and (*ii*), XY = 2TZ.

To this is to be added the height of the eye ZX, to get the full height of the tree XZ.

When the tree is middle sized, the middle needle I (*vide Fig.* 3 *above*) is aligned instead of point D with the top of the tree. In this case the actual distance on the ground is equal to the height of the tree, as the points A and I are equidistant from the point E, *i.e.*, 5 inches.

When the tree is very small the lower needle H which is at a quarter of the actual distance DE, is used. In this case the height of the tree is half of the actual distance on the ground. When in the forest it is not possible to get a position from where any of the above pins can be aligned with the top of the tree, a pin is moved on the axis of the indicator till it is aligned with the top of the tree. ....The height is then calculated in the way as given above, *i.e.*,

$$ZY = ZX + \frac{\text{Height of the indicator (In this case the distance between the pin and pivot E,)}}{\text{Distance AE } (=5)} \times AX \text{ or } TZ.$$

4. *Comparative Merit of the Instrument.*—This hypsometer has got several advantages over the other types of hypsometers.

(*i*) It is very easy to construct and ordinarily no minute graduations (as required in the Christen's dendrometer) are required. Further the height of all gradations of trees can easily and accurately be measured.

(*ii*) Brandis' hypsometer and Abney's level take much time for the measurement of the height of trees specially on sloping ground where the angle of elevation and depression have to be manipulated for the limits of their tables. Further a printed table is a necessary accessory to the easy use of these two instruments.

(*iii*) As regards Weisse's and Smythies' hypsometers, they do not give correct results specially on steep slopes as the actual sloping distance which is more than the horizontal distance is taken for calculation instead of horizontal distance.

(*iv*) In construction it is cheaper than Abney's level, Brandis' and Wiesse's hypsometers.

(*v*) Finally, the inaccuracies due to assumption of equality of sloping distance to the horizontal one, especially in cases of steep gradients, are entirely dispensed with as will be apparent from proof given in para 3 above.

Part B

5. *Measurement of Angles.*—This instrument can also be used to measure angles of elevation or depression on slopes by fixing a metal or wooden protractor on the axial rod AB with its centre at E (*vide Fig.* 4). It is graduated from its middle point H as 0° to 90° on each side. The slot in the axis of the indicator then reads on the protractor angle of elevation on the outer side (*i.e.*, towards the end B of the instrument) and the angle of depression on the inner side. Thus heights of trees can also be measured by measuring angles and consulting tables for Brandis' hypsometer.

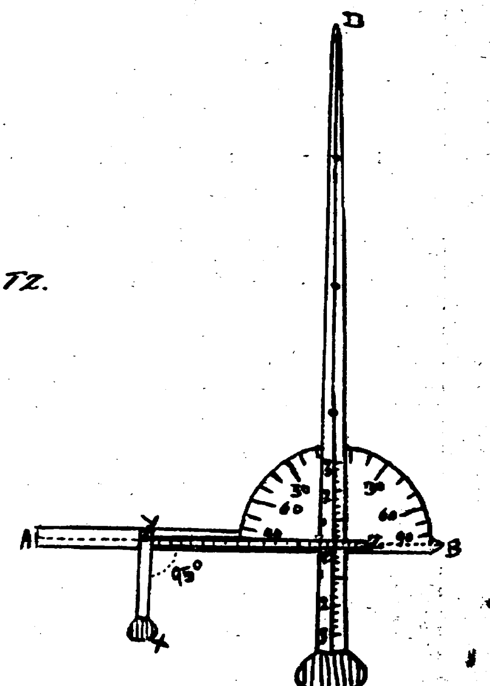


Fig. 4

Part C

6. This instrument can be further elaborated to measure the actual and horizontal distances to objects and also the vertical rise of fall of slopes by attaching the *Extrapiece* XYZ (*vide Fig.* 4). Two thin strips of wood $\frac{1}{2}$ in.$\times 4\frac{1}{2}$ in. and $\frac{1}{2}$ in. $\times \frac{1}{2}$ in. are taken and rivetted at their ends at an angle slightly greater than 90° (say 95°), in order to balance the horizontal arm YZ, $\frac{1}{4}$ in. being left on the smaller arm. This is then pivotted at Y on the main axis of the instrument at 4 inches length from E. This pivot Y lies on the axis AB and in line with the upper edge of the arm YZ. The long arm of this *Extrapiece* is graduated from Y as zero in units (inches taken in construction) and tenths of unit. The axis of the indicator is similarly graduated above and below E which is at zero. The end X of arm XY is so weighted that the arm YZ remains horizontal when allowed to move freely.

7. *Measurement of actual distances to objects.*—In Fig 5, P is the point to which actual distance YP is to be found. Place a pole OP of a known length vertically at P and direct AB to P. Move the arm YZ of the *Extrapiece* till its upper edge comes in line with the upper end O of the pole. Read the length EZ on the indicator.

In Fig. 5 $\triangle$OPY and $\triangle$EZY are similar, as OP and ED are parallel both being vertical.

$\therefore$ YP : YE = OP : EZ ....(*i*)

or YP = YE x OP/EZ.

YE = 4 in. as shown in para 6 above,

OP = length of the pole which is known and which is usually taken as 10 ft.,

EZ is measured.

Thus YP can be calculated easily.

In the above equation YE is a fixed quantity and if we suppose to use 10 ft. pole, then YE x OP is a fixed quantity equal to 40. Thus as long as a pole of 10 ft. height is used actual distance will be given by dividing 40 by EZ. If long distances are to be measured longer pole may be used and the calculations done accordingly.

8. *Measurement of the Horizontal Distance.*—After finding the actual distance

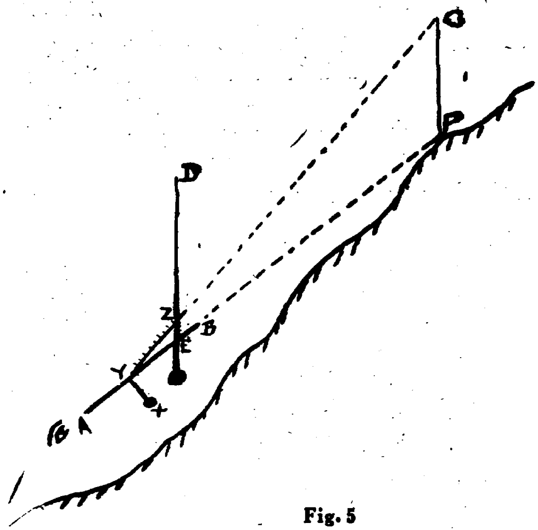


Fig. 5

by the above method the *Extrapiece* XYZ is allowed to move freely and the axial piece AB is aligned with point P. Arm YZ (*vide Fig.*6) then cuts the indicator DEF at Z′.

Now in Fig. 6

$\triangle$YPP′ and $\triangle$YEZ′ are similar—as PP′ and EZ′ are vertical and hence parallel, and $\therefore$ YP : YE = YP′ : YZ′

or YP′ (horizontal distance)$=\frac{YP}{YE}\times$ YZ′.

In the above equation YP, the actual distance is known; YE is known-4 inches; and YZ′ is measured. Thus YP′ is exactly known by calculation. It can therefore be generalised that the horizontal distance to an object is obtained by ~~multiplying~~ the actual distance by 4 and multiplying it by the reading on the arm YZ.

dividing

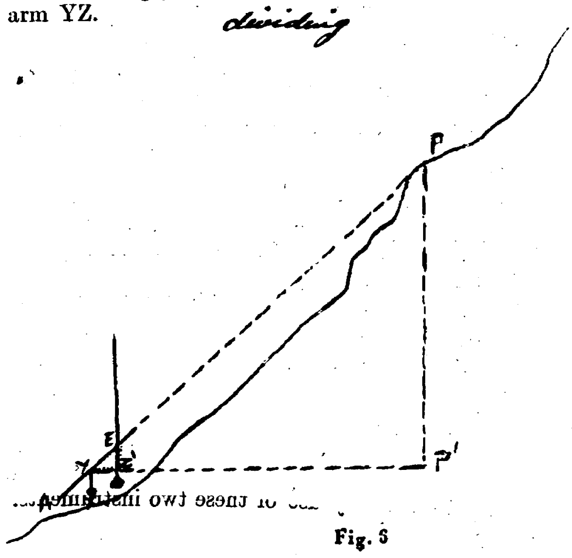


Fig. 6

9. *Measurement of vertical rise of slopes.*—The same procedure as given in para 8 above is followed. Read EZ′ (*vide Fig.* 6 *above*) on the axis of the indicator. From the same Fig. 6

PP′ : EZ′

YP:YE=~~EZ′~~ as △ YPP′ and △ YEZ′ are similar

or $PP'=YP\times EZ'/YE$ ....(*ii*)

All the quantities except PP′ are known and therefore the value of PP′ can be calculated.

By combining equations (*i*) in para 7 above and equation (*ii*) above

$$PP'=\frac{YE\times OP}{EZ}\times\frac{EZ'}{YE}=\frac{OP\times EZ'}{EZ}=\text{length of}$$

the pole used (in Fig. 5)$\times\frac{EZ'\text{ (Fig. 6)}}{EZ\text{ (Fig. 5)}}$.

That is, even without knowing the actual distance the vertical rise or fall can be calculated.

10. *Measuring the gradient of the Slope.*—in Fig. 6

△YEZ′ and △ YPP′ are similar,

∴ EZ′:YZ=PP′ : YP′=Gradient.

EZ′ and YZ are measured and the gradient can be calculated. For convenience sake this is marked on the indicator at different distances.

The *Extrapiece* XYZ is useful when the tape cannot be used conveniently *e.g.*, across the river or a *nalah* which is difficult to cross. It also gives the gradient of slopes directly and in less time than taken by the Abney's level. This instrument can be easily employed in topographical surveys specially contouring.* For ordinary use of measuring heights of trees the *Extrapiece* can be conveniently detached.

11. In short this instrument measures

(*i*) Heights of trees,

(*ii*) Angles of depression and elevation of slopes,

(*iii*) Sloping or actual distance,

(*iv*) Horizontal distance,

(*v*) Vertical rise,

(*vi*) Gradient of slopes.

Thus the complete instrument is not a simple hypsometer but a **Disto-Clino-Hypsometer** (*i.e.* an instrument which measures distances, angles and heights).

12. *General note on the construction and use of the instrument.*—A working model of the instrument was made in the workshop of the Forest Research Institute, Dehra Dun, which was found to work quite satisfactorily. The indicator can be hinged in the middle so that the instrument can easily be put in a small case. In its working it was found that the observer has to change the position of the eye after sighting the axis AB, in order to see the ray passing through the pin and the top of the tree (in Fig. 2 prolongation of YA gives the second position of the eye). It is very difficult to keep the hand firm in one position in practice. So the use of a simple stand on which the instrument can be fixed by its side, is suggested. However, this will affect the general utility of the instrument as a stand will need to be carried. To avoid this, length AE is reduced to $4\frac{3}{4}$ units and the eye is fixed at point A. In this case the eye itself takes up the position of the sighting pin at A (which was at 5 inches) $\frac{1}{4}$in. being approximately the distance of retina from the edge A. While weighting the indicator and the *Extrapiece* care should be taken that the weight is attached equally on either side to avoid lateral tilt.

In the design of this instrument the principle of the hypsometer designed by Professor Dr. Kunchel has been employed.

When a more durable model is made, it would be worthwhile comparing its performance with that of the other hypsometers.—*Ed.*

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*This aspect will be elaborated upon in a subsequent article.

RAINFALL INTENSITY

By JAGDAMBA PRASAD, B.Sc., LL.B., P.F.S.
(*Experimental Assistant Silviculturist, F.R.I., Dehra Dun*)

In dealing with erosion control, specially with the design of drainage systems, the length of slope per trench, etc., the most important data are those of the intensity of the rainfall. SAUSMAN (*Indian Forester* of March 1946, page 116) has pointed out in the case of the Bijapur district of Bombay that the average annual rainfall figures are of little use as a precipitation of six inches may be expected in 24 hours out of the annual average of 18 inches. The spacing of 70 ft. horizontal distance between two trenches resulted in an insufficient accumulation of water in a trench to help the young seedlings to tide over the two month period of drought, and a 150 ft. distance had to be adopted with a 3 ft. interval after every 200 ft. of trench to carry away the surplus water.

We have recently obtained from the Indian meteorological department figures of rainfall in each hour for 5 stations, and two-hourly records for two stations in India. Incidentally these are the only stations for which such records are available.

In the United States of America the records show accumulated amounts of precipitation during all storms on which the rate of fall equalled or exceeded 0·25 inch in any five minute period. This corresponds for our purposes to limiting values of 0·8 inch in any one hour period and 1·4 inch in any two hours period.

The following table shows the details for the seven Indian stations.

Serial. No.	Station	Average annual rainfall in inches	No. of rainy days and average rainfall per day in brackets	Average No. of periods of high rainfall intensity	
				Hourly	Two hourly
1	Bangalore	34·1	57 (·60)	1	..
2	Bombay	71·2	74 (·96)	..	19
3	Calcutta	63·0	84 (·75)	10	..
4	Lahore	19·2	28 (·69)	..	..
5	Madras	50·0	57 (·88)	4	..
6	Mahabaleshwar	261·2	120 (2·18)	94	..
7	Simla	61·0	88 (69)	..	9

There is thus no correlation between the rainfall intensity and either the average rainfall or the number of rainy days. The table also shows how misleading the annual rainfall figures can be.

The silviculture branch of the forest research institute has an automatic recording rain gauge on order and we hope soon to be able to collect our own local data on rainfall intensity.

At the same time, American research has demonstrated that, as a basis for the design of improvement works conclusions respecting the probable intensity and frequency of rainfall data in a given area are far safer and more economical if drawn from a study of the occurrence at many stations than if drawn from 25 or 50 year records from only one station. It is necessary therefore to have a network of such automatic rainfall recording gauges, in the various parts of the country.

In this respect it is realised with regret that we are far behind America. Calculations of the rate of run-off in cubic feet per second by RAMSER'S* formula cannot be done unless we have these rainfall intensity data.

*Q=C. I. A.
where Q=rate of run-off, in cubic feet per second.
C=The run-off coefficient, a fraction stating the portion of rainfall that appears as run-off and depending upon the character of the drainage area.
I=The rate of rainfall in inches per hour.
A=Drainage area in acres.

These recording rain guages are expensive (about Rs. 500 each) but the question of funds should not be a deterrent, for one thing, as the data required are fundamental for the adequate and economical design of erosion control works. Secondly the irrigation department can be and should be induced to provide funds on a co-operative basis. The departments concerned with electric power systems are also interested as they adopt a wet test for insulators of 3 mm. per minute and would like to know the frequenency of occurrence of an intensity exceeding this limit, in the various spheres of their operations.

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EXTRACTS

WEEDING AND CLEANING

By W. L. Taylor, C.B.E.

As with most of forestry's routine tasks, the weeding and cleaning of plantations are, *prima facie*, operations of a simple nature. The objects are to protect the young crop from being smothered or otherwise interfered with by wild vegetation (Weeding), and as the plantations progress to keep them free from intrusive growths of bramble, briar, and honeysuckle and any coppice shoots, natural saplings, or other unwanted growth that may occur among the planted species (Cleaning).

It goes without saying that weed competition can do untold harm in a young plantation, even to the extent of ruining the whole planting. Annual and other herbs often threaten to overwhelm small newly planted trees by the sheer weight of their lush growth, while dense growths of the stiffer-stemmed kinds of weeds are also frequently damaging.

All wild plants growing in a forest that are not necessary or helpful to the formation of the prescribed crop come under the general heading of forest weeds, although not all those that may be present are actually inimical. When surrounded by lusty weed species possessing all the advantages to be derived from an accustomed habitat, a young plantation which has not yet established itself is at considerable disadvantage in its early fight to attain supremacy, a handicap which extends below ground as well as above because root competition is also severe.

Foresters have to contend with numerous types of weeds, annual and perennial, herbaceous and woody, and trailing and climbing. In a new planting the wild herbs, fern, heather, whin, brambles, and coppice shoots are all potential causes of trouble. Bracken fern is one of the mosts serious foes to a young forest crop. At later stages the climbers, briars, coppice, and minor tree species (intruders) enter into the picture.

Injury in a number of forms results from uncontrolled weed-growth: Smothering, with exclusion of light and air, resulting in etiolation, breakage, distortion, and in dank conditions under a dense mat of vegetation, to increased risk of losses from moulds and fungi.

Damage to stems, leading shoots, and foliage, by whipping and chafing, resulting in distortions and lesions affecting height and crown development, nutrition and proper growth, and the quality of the timber, besides affording means of access for the spores of fungi.

The premature suppression of side branches and consequent inducement of top-heavy development and instability.

Strangulation by climbing plants.

Enhanced danger from frost where certain types of weeds predominate among the ground flora, *e.g.*, fine grasses.

Competition in the soil for moisture and nutrients, and excessive transpiration of available moisture.

As plantations develop, by the production of whips and weakly stems due to overcrowding.

Weeding and cleaning are described above as routine operations of forestry, but there is, of course, more in the proper supervision of these operations than mere routine. It is necessary to know when to weed, how to weed, and how to decide the more difficult problem of when it can be regarded as safe not to weed. Failures are bound to follow if necessary weedings are neglected. At the same time weeding is a costly operation which must sometimes be repeated twice or even three times in a season and to overdo it becomes unnecessarily expensive; in forestry, as in everything else, a penny *legitimately* saved is a penny earned. In general, the need to weed will be obvious to the forester. It is not so easy to recognize when a weeding can be avoided without risk to the crop, a matter in which both the value of observation and need for experience are abundantly demonstrated and cannot be overestimated. A point always arrives at which the expense of weeding to save an odd tree here and there in a fully stocked plantation is not justified. If an experienced and observant forester, after carefully assessing the circumstances before him, is confident that his plantation will come to no harm, or a negligible amount of harm, then it may be considered safe to say that weeding is not necessary. But where doubt arises and no other reliable

confirmatory opinion is available for consultation, weeding ought never to be delayed. This aspect of the weeding problem is important because a stage is always reached in the early life of a plantation at which the need to weed ceases.

In addition to otherwise unwarranted expenditure on beatings-up to replace trees killed by weeds, the penalty for inattention to timely weeding is, at the best, a weakly, ill-furnished, gappy, and leggy plantation that is more or less unstable and unhealthy; at the worst the planting may have to be written off as a failure. If it is taken as a truism that weeding is always necessary when judgment based on experience points the moral, then, equally, it is wrong to continue to weed blindly season after season as side branches lengthen and height growth draws away from the level of the weeds. *Experientia docet,* but until the required degree of experience is gained it is wise to keep to the safe side.

The essence of all successful silvicultural tending is frequent inspection followed by speedy action where action is called for. Watchfulness is the best of all safeguards against neglect of weedings and cleanings as it is in regard to any other of the seasonal operations of forestry. Weeds grow exceedingly fast, often a few days' growth makes all the difference. On no account must newly planted areas be allowed to get overgrown, nor does it do to be complaisant when the first flush of wild herbage has been dealt with, because secondary summer and autumnal growth may also be lush, particularly during wet seasons. The effects of seasonal vagaries of the weather are apt to make weeding operations more onerous. Weed growth is frequently unexpectedly profuse during a wet and mild autumn, especially on grass areas; again in a region in which rainfall is normally low, a wet summer season will induce a much stronger growth of weeds than is usual. These are occasions on which the forester may find himself caught out if he is not careful. Pending establishment it is imperative that no chance of making headway be denied to crop.

To be fully effective, necessary weedings must be carried out promptly and completed before injury is sustained. Always attend first to the areas in which the most urgent danger lies, never forgetting that a plantation may look safe for the moment and be at risk a few days hence owing to the rapidity with which weed-growth develops. Gaps in a plantation can frequently be traced to patches of weed that have been overlooked, particularly of such weeds as bracken, bramble, gorse, aspen suckers, seedling birches, rose-bay willow-herb. *Airia caespitosa*, *Molinia*, *Funcus*, or *Calamagrostis.* All these often occur quite locally in plantations; such patches may need weeding for some years after the rest of the area is safe.

Do not be caught napping. Weeding-gangs should be directed daily to the areas most in need of attention and not left to plod their way stolidly through the plantings without regard to day-to-day local conditions. The nuisance value of a weed depends largely upon its luxuriousness and density, and it is the 'pure' patches of strong-growing weed species that are the chief danger.

The methods used in planting influences risk from weeds to a considerable extent, as will be seen in turf-planted areas or where planting is done along the ridge, or at the side, of the furrow on deeply ploughed land. In these circumstances, the young plants have a much better chance of holding their own than they have when planted on the flat in the midst of a well-established natural ground flora.

The types of weed-growth present on the ground, the densities in which they grow, the species of tree planted, the method of planting, and the progress of the plantation are the notable factors. In certain circumstances a moderate amount of stiff-growing weed affords temporary shelter from sun, frost, and wind; consequently there may be benefits to be obtained on occasion by intelligent manipulation of weed-growth of this description, but no suspicion of smothering or overcrowding can be tolerated. For instance, heather and bilberry will give protection from blast on exposed heaths and any weed-growth there may be on open chalk down land affords shelter from sun-scorch that is of especial help to beech. Weeds with a tendency to flop over the young crop are potentially harmful in almost any circumstances in the first few years.

Stool shoots are the bugbear in coppice areas. Of coppice weeds chestnut is the greatest aggressor if neglected; lime, oak, birch, and ash come next in order. Expertly handled moderate coppice growth is capable of affording protection to and nursing up some species of hardwoods, but in the great majority of cases, in conifer plantings in particular, it pays best to deal drastically with coppice shoots until the stools are so

weakened as to become harmless or until the crop finally overtops all weed-growth of this description. In the first years the only sensible thing to do is to keep the stools closely cropped by slashing away all annual growth as it occurs; the slower an introduced species is to establish itself the more necessary it is to be ruthless with coppice. Where the annual shoots of coppice are cut while still sappy the stools are weakened more quickly. Gorse and broom also require drastic treatment.

Young conifers need complete freedom to expand their successive whorls of branches until the plantation begins to close in, and they must have clear head-way for their leading shoots. If leaders are interfered with and the natural leaf-spread restricted at this period, development is bound to suffer and the general health and well-being of the plantation is imperilled.

It is very important to realize that pines and larches must be weeded *early* in the season and kept completely clean from weeds for the first years. Attention to the spruces can usually be deferred until rather later in the season because, during the first weeks of summer, they will not suffer from weed-growth that would be irretrievably damaging, for instance, to Scots pine and European larch in the same period.

Young hardwoods also require light, air, and space, but everything is not yet known about weeding requirements and weeding technique in regard to young oak, beech, and ash, in all the various vegetative conditions which prevail on soils for which these trees are suited. Where small transplants or seedlings are used there is no doubt that oak and beech must at first be weeded early and thoroughly. Ash and sycamore are (or should be) taller when planted out and for them the urgency on the average site may not be quite so serious. Nevertheless, hardwood species must not be permitted to become overwhelmed by weeds to the detriment of their spring and summer growth. Nearly all young broad-leaved trees are highly susceptible both to late frost and drought and in some conditions undoubtedly appear to benefit from the shelter of a moderate amount of natural growth round about. In this there is room for more recording and assessment of the rusults of further observation; the one thing that is certain is that all species of young trees need to be given light and air and the growing-space proper to their several requirments at all stages of growth.

But, apart from smothering, weed-growth on naturally dry soils, especially coppice, tends to draw more than its share of moisture and is capable of drying out the surface soil excessively. This has been suggested as one of the major factors accounting for the indifferent success of the replanted mixed belts in East Anglia.

Weeding may be complete, that is to say all adventitious growth on the area is cut back, or it may be selective around individual plants needing more freedom. It is usual to cut all excessive weed-growth at least in the first and second year's weedings. As already stated, the crux of the matter is to be able to realize when weeds are harmful and when the young planting can be regarded as so far eatablished as to be free from weed dangers.

When the crop has begun to close in it is time to begin to think about cleaning. In afforestation there is usually a gap of at least 5 years—it may be as long as 10 years—between the last weeding operation and the first cleaning, but in some types of plantations there is no hard-and-fast dividing line between the two operations; in such conditions it may be hard to define where weeding ends and cleaning begins.

Cleaning a plantation is the operation of cutting out the taller growing, woody, weed species, climbers, and naturally regenerated stems that are redundant where not of use to make good gaps in espacement either temporarily or to take a definite place as part of the forest crop; intrusive birch and other hardwoods can sometimes be utilized to fill up in these ways. What is necessary is to prevent overcrowding and injury to the planted trees and to facilitate access for inspection within plantation which at this stage, as in the earlier and most of the subsequent stages, should be frequent. If his footprints are the best dressing a farmer can give his land, then the forester's eye affords the best assurance against forest ills. Frequently one cleaning suffices, any further unwanted tellers and coppice poles being removed in course of the early thinnings. The operation is one for the winter months.

At this period it is usually convenient to cut regular 'racks' across the compartment to give access to the interior for inspection purposes. If the crop is sufficiently advanced, cleaning is combined with brashing, or the knocking or cutting off of the lower suppressed branches

throughout the plantation, preparatory to marking a first thinning, to afford free circulation of air, and to give protection against fire at this hazardous stage. Opportunity can also be taken to cut out the more obvious of the genetically bad, excessively branchy, or distorted trees stems that must in any case be removed in the near future—although the general warning that every strong-growring tree, otherwise of good type, is not of necessity a 'wolf' tree must not be ignored. Foresters must be guided by circumstances in attempting to combine these operations, also in regard to the extent of brashing that is necessary; cleanings cannot, however, always be allowed to wait. However, where cleaning has been deferred to a relatively late stage, brashing will be found essential to enable workers to penetrate into the plantation.

The choice of tools for weeding and cleaning is not very wide. For weeding, the short-handled bagging or reaping hook, of which, there are several patterns, is much superior to the long-handled tool, and if used with a stick or crook carried in the left hand for freeing individual tree stems it is certainly the best all-round weeding-tool in general use. With the long-handled hook there is less control, but with either type, if badly handled, it is possible to slash off leaders and maim large numbers of young trees—inexperienced or careless hands the 'Sheffield rabbit,' can be almost as destructive as its living counterpart.

Existing types of mechanical weed-cutters have a limited field of utility in the plantation. The Allen motor-scythe and others have their uses on relatively level ground where the weed-growth is composed mainly of grasses and other soft herbs, but to enable these power tools to be used effectively the plantings must be regular and the rows well defined. In most cases mechanical weeding requires supplemental hand-weeding between the trees to make a good job of it.

The proper tool for cleaning is the bill-hook, of which there are many local types. Like all edged weapons, a bill-hook is only effective in experienced hands; indeed, if unnecessary damage is to be avoided, and the risk of personal accident reduced, no worker should be allowed in the plantation with a tool with a cutting edge until he is thoroughly accustomed to its use. Unless the workers are highly skilled it is always advisable to make use of the hand-saw for brashing persisting side branches.

All weeding and cleaning tools should be kept clean and sharp or slipshod work may confidently be looked for. Tools should be wiped and oiled after the day's work and the hone applied as soon as edges give sign of becoming dull. Saws must be kept properly set.

Both weeding and cleaning impose hard wear on clothing. Materials should be as resistant to thorn and briar as possible, and to wet conditions, because weed-growth is often saturated with rain or dew. For weeding, rubber Wellingtons are suitable; strong leather boots and leggings are advisable for cleaning work.

—*Forestry*, Vol. XIX, 1945.

THE SIGNIFICANCE OF FOREST IN GEOGRAPHICAL STUDIES

(A lecture delivered by Dr. R.M. Gorrie to the Punjab University Geographical Society).

In spite of heavy war-time fellings the hill forests which are economically the most imporatant, have not been dveloped to their full commercial possibility. The chief reasons are in the lack of communications and in large tracts of valuable forests being unworkable owing to their inaccessibility. Steady progress has been made in their development by the gradual extension of roads and railways, but the main means of extraction must remain by floating timber down the Punjab rivers.

There are 6,078 sq. miles of forest land in the Punjab or 6.7 per cent. of the total area of the province. Of this 2,067 square miles are under conifers, and 4,011 square miles under broad leaved trees. Small as the total forest area is compared with other Indian provinces, the position from the economic point of wiew is even less satisfactory than would superficially appear, because in the case of conifiers the area unprofitable, for working is 64 per cent., while in broad-leaved forest 90 per cent. is unprofitable. The quantity of wood found growing per square mile of the forest area varies within wide limits, but is on the average estimated at 906,000 cubic feet for conifers and 219,000 cubic feet for broad-leaved forests.

There has been a popular impression in the

Punjab that the whole of the hill country and other wild lands of the province are being looked after by the forest department, but actually this department holds only a very small percentage of the vitally important foothill drainage areas, and even in the forest reserves its hands are tied by legally binding but ridiculously generous forest settlements under which effective control of grazing and other destructive customs is more or less impossible. The remainder is in village lands and in several Indian states, where over-grazing and other misuse of lands, such as bad cultivation methods, are widespread.

RIVER CATCHMENT AREAS

The entire flow of a river can seldom be used by man, for a large percentage is inevitably loss in uncontrollable floods. The measure of a river's efficiency is its average flow—in the case of town supplies, its average clear-water flow. Anything that interferes with the regularity of this flow is of importance. Any increase in the run-off from rain will tend to increase the effects of erosion also, and floods are the cumulative effect of both. Similarly, droughts are intensified by any reduction in the efficiency of a catchment area because a poorly covered slope loses a large percentage of rainfall and the reserves that feed the deeper springs in times of suface shortage are thus depleted.

The remedy lies, of course, in the maintenance of a plant cover on the vulnerable foothill areas. In the Punjab the destruction of the plant cover of the foothills is an extremely complex problem, the seriousness of which, has so far been realised by only a few.

The Western Himalaya rises from the Punjab plains in a series of outlying ranges, gradually increasing in height from the outer low ridge of the Siwaliks, only a few hundred feet above the neighbouring plain, to the main ranges, 60 to 80 miles beyond, with their 20,000-feet peaks. An exception is found in Kangra, where the stupendous cliffs of the 15,000 foot. Dhauladhar tower above the outermost valleys. The rainfall decreases rather rapidly from south-east to north-west along these hills. From a total of about 120 inches above the Kangra valley it decreases to a scanty 30 inches at the same altitudes in the Rawalpindi and Razara hills, and on the plains it decreases from 40 inches to 10 inches from east to west.

There is also a marked altitudinal variation because the full force of the monsoon storms strike the hills at about 4,000 feet. Both about and below this wettest belt the rainfall decreases appreciably, and the winter snowfall reaches an appreciable depth only above 9,000 feet. Hence it will be seen that the foothills bear the brunt of the onslaught of the monsoon storms, and their condition is a vital factor in the water conservation of the province.

A further serious source of damage to the plant cover that nature originallv provided is to be found in the system of field cultivation used in the higher hills up to the level at which summer cnltivation is attempted namely about 10,000 feet.

In the lower hills and on gentle slopes the standard of terracing is on the whole fairly good, and in certain tracts, such as the Jhelum Salt Range the method of levelling fields is very efficient indeed—by means of either stone walls or ploughed earth scooped up into contour ridges. This, however, is the exception, and elsewhere the use and maintenance of *watt bandi* (the Punjab equivalent of contour ridging) are sadly neglected or unknown.

In the hilly and more primitive tracts the steepest hill sides are stripped of their cover, often by burning the forests, and are dug by hand because they are too steep to plough. The result is an appalling waste of soil which is washed away at the rate of as much as 150 tons or even 200 tons an acre a year, and each field is capable of producing potatoes for only three or four years, after which it reverts to village grazing.

Persistent grazing prevents the reestablishment of the previous forest cover, and the ground is eventually reduced to a bare and unstable screen of stones. With this destruction taking place over large areas of extremely steep country exposed to the terrific onslaught of the monsoon rains, it can be imagined just how serious the effect is likely to be on the water regime of the country as a whole.

THE FORESTER'S CONTRIBUTION

So far back as 1870 forest officers have constantly been calling attention to the serious denudation of the Punjab foothills, and the disastrous results which must inevitably

follow. In addition to deloping to a high standard the management of the relatively small part of the province, which they were given charge of in the form of forest reserves, they have foretold the inevitable effect of persistent overgrazing on the areas outside the forest reserves. It is, however, only since the introduction of the rural reconstruction programme that they have been given any opportunities to deal effectively with this menace outside the limits of reserved forests.

Until recently the Punjab forest officers have advocated closure to grazing as the only feasible means of restoring the plant cover to its natural condition, and thus reducing the runoff and loss of soil. This, of course, is still the main line of attack but considerably more can be done if the various phases of misuse of land are taken up under improvement schemes which deal with bad agricultural as well as bad grazing methods, and a better conception of the essentials of sound livestock farming is shown by demonstration and education, rather than merely insisting upon reduction of the sheer weight of numbers of cattle and goats.

Much of the erosion loss occurs in areas where so far no department of the government has made itself responsible for teaching new and improving local methods. Therefore, in projects recently outined the need for closer co-operation between forest, agriculture, veterinary, animal husbandry and revenue staffs has been emphasised. Fundamental changes in the lives of the very conservative farmers and graziers cannot be brought about suddenly, and can only be affected by a long-range programme working steadily towards the aims in view. The various lines of approach can perhaps best be summarised under the three headings of plough-land, live-stock with fodder production and afforestation works.

The Punjab forest department has made a very large war effort by producing 7,000 tons of sawn timber from its temporary saw-mills at Ravi Park, Jhelum and Abdullapur. This timber was extracted from Kashmir forests as well as from our own Punjab ones and floated down the Punjab rivers to the plains. Great areas of hitherto unworked fir forests have been exploited and a total of over six million cubic feet of fir timber has been brought out for war work.

The irrigated plantations on the plains and many miles of canal avenue have produced *sissoo* logs for which the war time demand was insatiable. It the war demands did nothing else, they established *sissoo* as one of the finest hardwood timber in the world and so we can be sure of a good financial return from the many thousands of acres which we are reclaiming from sandy torrent beds and converting into *sissoo* forests. Resin from the *chir* pine forests last years amounted to 75,000 maunds, the extraction of which gives good employment to many hill villagers.

The total forest revenue for the Punjab in 1944-45 was a crore of rupees and the average surplus over the last five years is Rs. 17 lakhs.

Another important item is *bhabbar* grass for which the Jagadri paper mill paid Rs. 13½ lakhs for 1,60,000 maunds. But this went almost entirely to village owners in the Siwaliks and is not included in our departmental revenue as it is largely the result of the villagers co-operative action in securing closures to grazing.

The Civil & Military Gazette, June 13, 1946.

SANE FORESTRY

Old Woodland Soils Yield Best Results—Superiority of Mixed Woods

By Sir Alexander Rodger

An article in the *Timber Trades Journal* of December 9, 1944, entitled "Old Woodland Soil", by Mr. Ray Bourne,* deserves the attention of all woodland owners in the kingdom. Few experienced foresters will differ from Mr. Bourne in his opinion that it is more important to take in hand the old woodlands than to concentrate on covering the country with blocks of conifers. Mr. Bourne estimates that the yield in cubic feet would be considerably more from the old woodlands if properly treated than from the newly afforested areas.

*Reproduced in the *Indian Forester*, Vol. LXXI, No. 6, dated June, 1945, on pp. 203-204.

He says that "the old woodland soils in this country, on the average, are far more productive than the available afforestable land". And again, "it is highly probable, unless there is in the meantime a great change in the relative values of different species, that the value of the outturn from the old woodland soils will be almost three times that from the afforestations."

The writer, from his experience during seven years as a forestry commissioner, can endorse these conclusions. He was especially struck by the absence of all real effort to make the best of the old Crown forests, and to form mixed woods. It looks as if the policy of the first 10 years of the commission's work was still being continued, and that was apparently to show as large areas of empty land as possible planted up. It is to be feared that putting acres into columns in forms was too much the main object of the early foresters.

A Good Example

Another interesting point made by Mr. Bourne was the superiority of mixed woods, not in all cases, but on many aspects and soils. This came rather noticeably before the present writer when visiting in January 1946, a wood of five acres in the south of England planted and cared for by the owner of a small estate. This owner had studied forestry and had done a great deal of practical work on sound lines.

In 1912-13 he planted the five acres with a mixture of 14 species, about 6 ft. by 6 ft. in approximately the following proportions per cent : Larch 28, N. spruce 14, Scots pine 14, beech 14, Douglas fir 7, Austrian pine 7, Hornbeam 4, *Robinia* 4, Ash 4, Silver fir 4, Weymouth pine 1, *Abies balsamea* 1, Oak 1, and White poplar 1.

Owing to the owner's absence no thinning was done until 1930, but since then the plantation has been properly cared for, and it now presents a remarkable picture of a good young mixture.

Beech and hornbeam overtopped a number of the larch before 1930, but larch is now the principal species and there are many good poles, about 47 ft. high with a diameter at breast height of 7 in. and about 300 to the acre, with a good mixture of beech, hornbeam, Scots pine, ash and silver fir, the last named as a second storey. The canopy is good, and there are several hundred beech and hornbeam per acre. The ash is good and is confined mostly to one part of the area. Nearly all the Douglas were blown down in ~~1828~~ when several feet, higher than the others, although they were on the sheltered side. The Weymouth, *Robinia* and Austrian pine have disappeared. Some alder slips were put in to fill up blanks. The poplars were planted on one of the margins for amenity. The present aspect of the fully stocked plantation is remarkably pleasing, and all the thinnings can be used for estate work or firewood.

Something to Think About

This landowner, unlike the majority, made arrangements to replant some of his estate on which timber had been felled for war purposes. It is sad to record that he could not do so, because the area he was able to undertake was less than 10 acres, and no wire netting could be allowed. What are we to think of a government which allows such rules? The present writer is reminded of the efforts he made while on the forestry commission to help the owners of small woods. They were all in vain. Some support is lent to these views by Richard Jefferies, the author of a small book which has recently appeared, *The wood from the Trees*. This is not the first time that the post-war proposals of the forestry commission have been accused of want of enterprise and imagination, and the lack of any attempt to see the land problem as a whole, with the necessity for a complete survey, as already begun by Professor Dudley Stamp. Mr. Jefferies's book is very interesting and well written, especially the historical part.

Another author who gives foresters something to think about is the Earl of Portsmouth, who published in 1943 *Alternative to Death* (Faber and Faber). Although dealing mainly with agriculture, Lord Portsmouth has an interesing chapter on "Forestry and Farming". It is unnecessary to recapitulate his comparisons of forestry in Britain with forestry on the Continent, as this has been done frequently in the past, but this chapter is worth reading, if only for certain enlightened views that the author develops regarding the methods by which the forester can help the farmer, especially by means of shelterbelts, and small blocks of woodland where timber can be grown for use on the farm.

Lord Portsmouth draws attention to several rather unusual points of view, which are worthy of consideration by foresters. He says that forestry is in danger of becoming a specialised field for bureaucratic monopoly, that we have never had a national school of forestry, and that forestry has never been the main livelihood of a community as in many parts of Europe. He lays stress on the important role played by sport, and expresses the opinion that large stands of conifers "in ~~nomenclatur~~e" will, except in small pockets and on certain hill soils, probably disappear. Developing the theory that the forestry commission has no permanent and long policy as regards the use of land as a whole, although good work has been done in planting, Lord Portsmouth draws special attention to the need for farmers to realise the great use they could make of shelterbelts, hedgerows and orchards.

The present writer, when addressing a West Country branch of the young farmers' union, was struck by the limited extent of knowledge of the value of woods and trees near farms on the part of the members, but also by the fact how easy it would be to stimulate their interest in the subject. Small woods, which are often found on better soil, than our large new woods would, in time, become valuable sources of timber, if properly attended to, and would certainly prove their value to farmers, and it might be worthwhile to initiate a special campaign of lectures, film displays and other propaganda to bring the matter home to them.

—*Timber Trades Journal*, Vol. CLXXVI, No. 3628, March 9, 1946.

VOLUME 72 NUMBER 11

INDIAN FORESTER

NOVEMBER, 1946

FORESTRY AND FOREST PRODUCTS

On the invitation of the United Nations Interim Commission on Food and Agriculture, representatives of the United Nations met in Quebec on October 16, 1945, to sign the constitution of the Food and Agriculture Organization of the United Nations and to hold the first session of its conference. The membership of the Food and Agriculture Organization at the close of the session consisted of forty-two countries including India. With the formal establishment of the FAO the United Nations Interim Commission on Food and Agriculture ceased to exist.

In his letter dated January 15, 1946, from Washington, D.C., L.B. Pearson, Chairman of the first session of the FAO, transmitting the report of the first session of the conference of his organization to governments mentions the importance which the delegates from the governments of many different regions of the world attach to FAO. Their governments are anxious to take separate and collective action for raising levels of nutrition and standards of living, securing improvements in the efficiency of production and distribution of food and agricultural products, and bettering the condition of rural populations. They have created FAO to help them do these things. The needs are urgent; decisions cannot be postponed. There can be no delay, according to the chairman, in going about the task of building a peaceful, orderly, and prosperous world.

The work of the conference was divided in two parts. Commission A dealt with the broad subject of FAO policies and programmes—what the organization might do to realize its objectives. Commission B dealt with organization and administration—the necessary machinery through which the policies and programmes can be carried out. The conference also appointed Sir John Boyd Orr as Director General of the FAO.

The first of the new permanent United Nations Organization agencies is thus launched which is something new in international history and as such, has few precedents to follow. Mr. Pearson promises in his letter mentioned above that the FAO will bring the findings of science to the workers in food and agriculture, forestry and fisheries, everywhere; and it will bring the practical problems of these workers everywhere to the attention of the scientists. It will assemble, digest, and interpret information to serve as a basis for the information of policy, national and international. It can suggest action, but only through the activities of governments themselves can the objectives be finally won. They can do much to raise nutritional levels even in the most disadvantageous countries. They can improve agricultural production, even in regions of adverse climate and rural over-population, especially if industries are developed which offer new employment opportunities. They can better the management of their forests and their fisheries. They can work together in expanding and ordering their international trade. They can set about eliminating the disabilities of rural life. Behind governments stand the people—those who produce and those who use the products of the soil and the sea. FAO must know, says the chairman in his letter, what they are enduring, needing and hoping. Likewise FAO must explain to them the new conceptions it stands for and what these mean in terms of practical policies.

As mentioned above Commission A was assigned the task of outlining policies and a programme for the FAO of the united Nations. In the introduction of its report to the conference of the FAO, the commission says that to meet the broad assignment the commission set up six committees—on nutrition and food management, agriculture, forestry and forest products, fisheries, marketing, and statistics. These committees presented their reports to the commission in the form of suggestions to the Director General. The commission embodied these suggestions and recommendations in their report which the conference accepted and

which it commends to the Director General and to governments for their earnest attention.

Forestry, the introduction to the report of the commission continues, which is the partner of agriculture in land use, also faces big problems. One early task for FAO should be a world survey of forests and forest industries including the changes wrought by the war and the need for rehabilitation and re-equipment. Another on which FAO may inform and advise is the development for tropical and sub-tropical forests of policies which, besides improving the forest output, can check soil erosion, provide farmers with fuel (thus saving the animal manure they now burn), and halt the ever advancing deserts. FAO should encourage land utilization surveys and legislation to designate specific lands for agriculture or for afforestation. Over large areas afforestation is a prerequisite to better agriculture and better rural living standards.

FAO's services, continues the introduction, should be available to extend forest management practices, thus replacing policies of destructive exploitation by those giving a sustained yield in perpetuity. Forest products industries also merit study by FAO. Every year research is finding new uses—particularly chemical uses—for wood, and to the extent that forest industries can be diversified a very high percentage of waste in wood utilization can be eliminated.

A study of levels of consumption of forest products in different countries would reveal great potentialities in demand and would indicate the contribution to rising living standards which wood can make in the form of houses, furniture, paper, textiles, and other goods.

Readers will doubtlessly like to see the report of the commission on forestry and forest products which we reproduce below *in extensio* from the *Report of the First Session of the Conference of the FAO of the UNO* held at the city Quebec, Canada, from October 16 to November 1, 1945, and published in Washington in January 1946 :

"The need for public action to ensure continuous productivity of existing forests and to establish forests on desert and other treeless areas creates a situation in which the Food and Agriculture Organization can be particularly useful to member governments.

Public safeguards have been afforded the majority of European forests but for the far greater portion of the world no safeguards exist, and in such countries governments will undoubtedly seek assistance in co-ordinating their public control activities before destructive processes result not only in the loss of forests but in severe damage to the soil.

The problem of the world's undeveloped forests—especially those within tropical regions —presents a unique opportunity for FAO. These are the most heavily forested portions of the earth's surface. They represent the world's greatest remaining wood reservoir; they produce a far greater assortment of non-timber products, especially food, than any other forest region.

They also offer a temptingly rich prize to destructive exploitation and in a very real sense constitute a challenge to FAO, since it is the only existing organization capable of assuming leadership in bringing about their protection. FAO may play a decisive role in assisting and encouraging governments to adopt policies of conservative exploitation over these vast areas and avoid a repetition of the wasteful and destructive methods of the past with the inevitable antisocial results that follow.

Since public policies are a major factor in determining the fate of forests, the education of the general public and of forest owners must form an essential part of any broad forestry program. FAO can materially assist the nations in this educational work.

Large-scale utilization of forests and the establishment of large forest industries, especially in the undeveloped areas, often will be financed, in part, through loans by private or public international lending agencies. Good management of woodland on farms and other small holdings may be furthered and the owners, income increased through various forms of co-operative action. In both of these fields FAO can function as a clearinghouse of information.

Recommendations

1. *For early action:—*

   (a) FAO should collect, compile, and disseminate information as to forest policies of member nations and furnish advice and guidance as to forest management measures which properly may be required on public and privately owned forest land.

2. *Other recommendations:—*

(*a*) FAO should compile and disseminate to member governments educational material and information on educational techniques used by other nations, and should itself originate material such as motion pictures, exhibits, posters, and other devices for educating the public and the forest owner on the importance of forests and forestry in the general economy.

(*b*) FAO should encourage member governments having large areas of undeveloped forest to formulate policies leading to their immediate protection against destructive exploitation and to adopt scientific management. It should investigate forest management practices which have proved most satisfactory in the exploitation of these areas.

(*c*) FAO should be prepared to advise private and public international lending agencies as to the technical and economic soundness of projects for which loans may be sought. It should usually advise against loans for projects that will result in destructive exploitation of these forests and usually favour those which will prevent it.

(*d*) FAO should serve as a clearing-house of information on forest co-operatives and keep member nations currently informed on developments in this field.

Systematic Forest Management

The war has had both direct and indirect consequences upon the growing stock of the forests of many nations. Directly it has damaged and destroyed certain forest areas within the theatres of war; indirectly it has brought about serious forest depletion in many countries through emergency overcutting. In restoring this growing stock without causing serious disruption to the reconstruction program, FAO can play an important part.

In regions where in the course of centuries forests have been wholly or partly destroyed, as in south-eastern Asia and the Middle East, the restoration of forests is one of the indispensable steps toward soil improvement, efficient agriculture, and higher nutrition levels for almost a thousand million people. In helping solve the afforestation problems of member governments, FAO should take an active part.

There are other necessary steps that must be taken by nations before forest management can be intelligently applied. In many countries forest taxation is an important deterrent to adequate forest practices on privately owned or held forest lands. Land classification is also an essential step, and here too FAO can effectively assist member nations.

Recommendations

The committee on forestry recommends that FAO should take action in the following manner:

1. *For early action:—*

(*a*) FAO should investigate immediately the extent of forest depletion caused by war and assist the affected member nations in co-ordinating their efforts to rebuild their growing stock and increment.

(*b*) FAO should immediately begin to assemble world-wide information on methods, costs, suitable species and seed sources, and other data needed by governments desiring to afforest desert and other bare lands.

(*c*) FAO should at an early date initiate a comprehensive study and analysis of forest taxation laws and policy and be prepared to supply information and advice to governments on request.

(*d*) FAO should take the necessary steps to be ready to establish at its next conference session international standards for the certification of tree seeds and planting stock.

(*e*) FAO should assemble all information on developments in forest management during recent years and disseminate this material to member nations.

2. *Other recommendations:—*

(*a*) FAO should be prepared to send missions to advise nations in afforestation projects and should

keep member nations currently informed on developments in new techniques and use of equipment and with the names of available experts.

(b) FAO should collect and disseminate information on the techniques of land classification and assist member nations by making known the names of experts in this field.

Forestry, Forest Products and Rural Welfare

In many countries there is a close relation between the existence and management of *adequate* forest areas and the success of agricultural crops. Afforestation has transformed the Landes in France from an area of swamps and sand dunes, poverty-stricken and unhealthful, into a land of prosperity where agriculture flourishes behind the protecting forests. In India the lack of fuel over large areas has resulted in the use of cowdung as fuel, the land has been deprived of the manure which it would otherwise receive, soil fertility has decreased, crop yields are low, and general poverty and a low standard of living have resulted.

Forests are an asset in the raising of livestock, but uncontrolled grazing and lopping often lead to forest destruction. This is particularly true of the Mediterranean countries and of large tracts in Africa and Central Asia. In these regions some control of grazing is a necessity. In many countries mere regulation of grazing will recreate the natural forest ; grazing, better cattle, better milk supply, and improved health and stature will result—an upward spiral of prosperity instead of a downward spiral of poverty.

If uncontrolled grazing has been a potent source of forest devastation, shifting cultivation is as bad or worse. Again, however, it is *uncontrolled* shifting cultivation that is so harmful. Like grazing, cultivation can be controlled and woven into a system of forest management.

Forests are also indispensable in mountainous areas to prevent soil erosion and for watershed protection. Afforestation is a vital factor in desert control, and although the deserts of the world are still advancing this advance can be arrested by proper afforestation.

In all countries a sound economic policy calls for a balance between forests, agriculture and other economic activities. A prerequisite to this in some countries is the provision of equipment and the construction of access roads for forest exploitation and industries. Equipment is urgently needed in (1) countries which have suffered from the war, (2) developed countries which have never had modern equipment, and (3) under-developed countries, especially in the tropics, which have never had equipment of any kind.

To develop and maintain forest industries a labour force is required. If an adequate number of sufficient quality is to be obtained the wages and living conditions of forest labourers must compare favourably with conditions in the cities.

Farm woodlots are an important factor in rural economy. Apart from the cash received by the farmer as a labourer in forests during the off season, woodlots can be of value to him as windbreaks, for fuel and small timber supply, and as a source of raw material for cottage industries. But the difficulty is to ensure proper management to prevent disappearance of the woodlots in hands of unskilled or improvident farmers. A solution has been found in Scandinavian countries and in Switzerland by a system of co-operative management with state assistance and sometimes state control.

Recommendations

The committee recommends that FAO take action in the following manner:

1. *For early action:—*

   (a) FAO should study world needs for forestry equipment, give advice on the most suitable technical equipment, and assist countries through proper channels to acquire what they need.

   (b) FAO should collect and disseminate information on technical and other improvements achieved for forest workers in different countries concerning house construction, camp arrangement, hygiene, local education, medical facilities, etc., in order to be ready to advise governments.

2. *Other recommendations:—*

   (a) FAO should collect information on grazing and lopping and their effects, shifting cultivation and its

control, floods and soil conservation, and the control of deserts, and be prepared to arrange for missions of experts where necessary.

(b) Legislation already exists in certain countries to guarantee the protection of forests on watersheds. On this and on all the subjects under 2 (a), FAO should collect and disseminate information both of research results and of advances in management and should build up advisory services to assist governments.

Forest Products and Living Standards

Acceptable standards of living for rural and urban populations cannot be obtained by improvement in nutrition alone. Satisfactory shelter, fuel for heating and cooking, and pulp products for education and other purposes are equally essential.

The availability of adequate supplies of forest products has a direct bearing on standards of living. Nutritional standards, sufficiently accurate for practical purposes, have been established for many regions and occupational groups, but the need for similar standards relating to consumption of forest products has been recognised only recently.

Increased production of agricultural products entails, and is helped by, increased consumption of forest products for shelter for more livestock, for new granaries, for additional fencing, and for innumerable other purposes. Improved distribution of food requires the use of more wood and other forest products in the extension and improvement of transportation systems, while vast quantities of box boards and pulp and paper containers must be provided for the protection of food in transit.

The best way of arriving at the basic requirements for forest products needed to attain the desired standards in food production, shelter, education, and sanitation, is to make an appraisal of the consumption of forest products on a per caput basis, by countries, by regions, and by occupational groups.

The work recommended for FAO in this field is in the nature of a series of long-term studies and need not be undertaken during the organizational period.

Recommendations ;—

1. FAO should make a survey of per caput consumption of forest products, with an appropriate subdivision by countries, regions and occupational groups. Techniques must be developed as the work proceeds. The data collected in this survey should be correlated with any other studies that aim at evaluating standards of living.

2. FAO should develop minimum standards of consumption of forest products for comparable groups.

Forest Research

At many centres, forestry research could be rendered more productive if better information were available as to the nature and scope of similar work already done or in progress elsewhere. Comparison of research programs could lead to elimination of unnecessary duplication and to mutually helpful adjustments.

Forestry research organizations already united to bring research workers together, to further the co-ordination of research methods, and to organise co-operative research projects. Further development on these lines would be helpful.

Efficient and up-to-date abstracting and translation services are essential to research workers in all countries but are not at present adequate to meet all requirements. There is frequently much delay in applying valuable results to practice.

Many countries will need the assistance of experts in establishing and equipping new research centres, or in carrying out special projects.

Recommendations

1. *For early action:—*

(a) FAO should make a survey of all organizations engaged in research in any branch of forestry or in any field having a direct bearing on forestry. This survey should record the nature and scope of work covered by each organization, and its personnel, and should be published for general circulation among research workers. The survey should bring

out the need for additional provison for research in some fields of work or regions; FAO should encourage the filling of any such gaps.

(*b*) Surveys should be undertaken of the present state of knowledge in special aspects of forestry, notably those of current importance and interest, such as the regeneration of tropical rain forests. Expert advice may be called for in carrying out such surveys.

(*c*) Glossaries should be prepared in the principal languages, listing and defining all technical forestry terms in general use, and these glossaries should then be combined.

2. *Other recommendations* :—

(*a*) Steps should be taken to facilitate comparison of research programs with a view to such measure of co-ordination as would minimise unproductive overlap.

(*b*) FAO should approach the organizations that give abstracting services with a view to negotiating mutally helpful arrangements to ensure full coverage. Arrangements should likewise be made for any necessary translation.

(*c*) The results of research should be published promptly in the form best calculated to come to the notice of those in a position to apply them in practice.

(*d*) FAO should maintain contacts with and assist in co-ordinating the the research work of professional forestry societies.

Forestry Education

Progress in forestry and utilization of forest products will be impossible without large numbers of adequately trained men in the forest and factories. Many new forest areas are likely to be opened up. Forests already in use will be more intensively managed as utilization improves. The constantly increasing uses to which wood is put require more trained specialists in wood utilization. Trained foresters are needed to rehabilitate forests that have deteriorated through overexploitation, war damage, or lack of skilled management; large-scale programs of reforestation and afforestation will call for many qualified technicians.

Not only are greater number of foresters required, but their training must be more diversified and of a higher standard than hitherto.

While there are numerous excellent schools of forestry, many of the existing schools are inadequately staffed and equipped, and in some parts of the world where schools are most needed there are none.

Too few professionally trained men are at present employed in privately owned forests.

To complement and make effective the work of highly trained specialists, large numbers of additional skilled workers, both in the forests and in industry, are required, and facilities for training are urgently needed

Recommendations

1. *For early action* :—

(*a*) A comprehensive survey should be made of the existing institutions offering professional education in forestry and in the utilization of primary forest products, including their facilities for meeting the special requirements of privately owned forests and of forest products industries. This survey should include institutions giving subprofessional training.

(*b*) FAO should advise in the replacement of libraries or books destroyed during the war and in securing the material which has not reached the forest schools during the war years.

2. *Other recommendations* :—

(*a*) Advice should be available on the establishment of new forest schools, the drawing up of curricula, the provision and training of teaching staff, the acquisition of teaching materials and other related matters; and similarly on the further development of existing schools.

(b) FAO should collect and disseminate information on the establishment and development of training facilities for skilled workers in forests and forest products industries.

(c) Exchange of teaching staff between educational institutions and provision of facilities for travel should be promoted in order to ensure continuous contact with forestry practice and research.

(d) FAO should advise on the building up of libraries for new schools and the enlargement of existing libraries.

(e) Regional conferences of forest schools should be arranged for the discussion of such matters as minimum standards of professional training.

Forest-Products Research and Utilization

Forest-products research has indicated a great variety of new and promising fields for development in wood utilization, and a few nations have made important advances, but in many countries with extensive forest resources, utilization of timber is still very primitive. FAO may help stimulate progress in the use of wood by assembling, analysing, and disseminating information on new techniques in wood utilization.

Recommendations

1. *For early action:—*

(a) FAO should assemble, analyse, and disseminate data on recent progress and new techniques in wood utilization.

(b) FAO should assist in extending the knowledge of the utility of little known woods, especially tropical species, and foster the establishment of standard methods of testing the mechanical and other properties of wood species.

2. *Other recommendations :—*

(a) FAO should assemble information regarding the technical properties of the various materials in the world, especially in the tropics, suitable for the manufacture of pulp, paper, and related products.

(b) FAO should encourage research in the use of forest products in the construction of houses and of farm and other structures, as a part of a program for full employment and the raising of living standards.

(c) FAO should foster improvement in packing and transporting food and other commodities for export.

(d) FAO should assemble technical and statistical data on world production of minor forest products as a basis for the development or expansion of their uses.

Integration of Forest Industries and Reduction of Waste

Wood waste is a term loosely applied to material from logging or manufacturing operations which is put to no commercial use, and also to material burned for fuel which might be used in the manufacture of products of higher value. In some countries there is practically no waste; in others where timber is more abundant, waste may be as high as 75 to 80 per cent of the volume of a forest stand.

Much waste could be eliminated by integration of forest management and utilization, and by better integration of wood-using industries.

Recommendations (for early action):—

1. FAO should assemble data regarding the utilization of wood for industry and for fuel, especially from countries where a high degree of integration in forest industries has been achieved.

2. FAO should encourage increased efficiency in logging and manufacturing by the use of equipment best adapted for the purpose, and should foster research in techniques suitable for particular regions.

Statistics

If FAO is properly to fulfil its functions in the fields of forestry and forest products, it must have at its disposal up-to-date and accurate information respecting the extent and capacities of forest resources of the world and the supply of and demand for forest

products. International statistical series, instituted by several organizations before the war, should be resumed and consolidated by FAO at the earliest possible moment to serve the organization itself, forest authorities, and the forest-products industries of the world. These series covered production, distribution and consumption in the major wood-using countries, but there were many gaps as to production, and information on stocks was not entirely adequate. During the war greatly improved information has been collected and it is highly desirable that such statistical series should not be discontinued. It will be necessary to make arrangements whereby corresponding information will be made available for other regions where it is lacking. Attention is called to the fact that in some countries very valuable statistics, notably those concerning industrial output, stocks, and prices, are compiled by trade associations rather than by governments, and it is hoped that suitable arrangements can be made wherby these will become available to FAO through the proper governmental channels.

Through international co-operation centred in FAO, it is expected that general agreement can be reached on the most suitable framework for a body of world-wide forestry statistics. While it is recognised that different terms and units of measurement established by preference and long custom in different countries will continue to be used, each country should be asked to submit definitions of terms and to recommend suitable factors for the conversion of its units to whatever units may be adopted by FAO for regional and world-wide compilations.

Recommendations (*for early action*) :—

1. FAO should give priority to the resumption of statistical series interrupted by the war, and to the continuance for peacetime purposes of new series instituted during the war. This will involve an early approach by FAO to the governments concerned.
2. FAO should compile a catalog of all kinds of statistical series relating to forestry and forest products.
3. FAO should at an early date initiate consultations preparatory to a world survey and inventory of forest resources and industries. It should encourage governments to undertake national surveys according to an agreed pattern and should assist by assembling, analysing, and making available information on techniques, costs, equipment, and names of available statistical experts.
4. FAO should lose no opportunity to encourage and assist governments in improving the extent and comparability of forest statistics.

Marketing

Marketing has both national and international aspects. There is known to be great diversity in methods of grading closely similar species used for the same purposes and in acceptable sizes of products of forest industries as between different countries. These are of long standing, and uniformity will not easily be reached ; but confusing trade names and lack of well-conceived standard series of sizes and grades result in high costs of production, inefficiency in the use of wood as a material, and unnecessarily high costs to consumers. The first step for FAO will be to act as a clearinghouse for the collection and distribution of all available information on grading practices and units of measurement. Subsequently, progress towards standardization for improved utilization may be possible through international conferences to be organized by FAO.

Much useful work is being conducted by research organizations and other bodies in various parts of the world on the development of new uses for wood and in the utilization of unfamiliar species of timber. This provides a wide field in which FAO could act as a centre for the collection and distribution of information and thus provide a basis for a scientific study of consumers' needs.

It could also act as a source from which the trade organizations interested in extending the use of forest products could obtain authoritative and reliable information.

The committee has reviewed paragraphs 104 to 107 of the report of the technical com-

mittee on forestry and forest products* dealing with international trade in forest products and in general endorses the views expressed. In this connection it is stressed that the compilation and publication of adequate estimates of international supplies and requirements of lumber and other forest products would of itself exercise a stabilizing influence upon the market, as well as facilitate adjustments in production and demand.

Recommendations (*for early action*):—

1. Governments should be invited to establish national forest products balance sheets. These should then be collected and collated for the world.

2. Provision should be made from the first for the collection and distribution of information respecting measurement and grades of forest products, and of information relating to the efficient use of forest products and the introduction of unfamiliar species, in such a way as will permit the progressive development of activities through FAO.

Third World Forestry Congress

FAO should follow the precedent set by former world forest congresses in 1926 and 1936 by taking steps to call the third world forest congress in 1946 or as soon as possible thereafter.

Implementation of Recommendations

These recommendations have been kept to a minimum, but it may not be possible to carry out all of them during the formative period of FAO. The committee on forestry and forest products urges the appointment of a strong advisory committee on forestry and forest products at the earliest possible moment to help the Director-General in applying the recommendations of this conference and putting into effect the committee's suggestions for a world forest policy which is outlined in the pages that follow.

A World Forest Policy

The principles of a world policy together with a specific program for FAO have already been considered by the interim commission and laid down in a report of the technical committee on forestry and forest products accompanying the interim commission's third report to governments,† as well as in the report published as one of the five technical committee reports of the interim commission. The forestry committee approves and endorses the former as well as the general principles and recommendations contained in Parts I and II of the latter. The recommendations in Part III of the technical committee's report are replaced by the recommendations for early action contained in the report to commission A by the committee on forestry and forest products.

Delegates from many nations have presented before the forestry committee reports dealing with conditions and problems in the forests and forest industries of their countries as well as in a number of dependent areas. These reports have suggested the following broad groupings:

(1) Countries in which forests have not the capacity to supply domestic wood needs and which are forced to manage their forests more intensively and expand their forest area in order to increase their wood production and improve the quality of forest products.

(2) Countries still endowed with vast forests which should control cutting in order to ensure the continued use of their forest resources at a high level, since the experience of the last twenty years has amply demonstrated that forests once considered inexhaustible can rapidly be exhausted.

(3) Regions now suffering acutely from the results of deforestation with its attendent disastrous influences on climate, soil, and rural economy and which therefore need afforestation policies.

(4) Countries, especially in the tropics, having vast and dense forests

*United Nations Interim Commission on Food and Agriculture, *Five Technical Reports on Food and Agriculture*, Washington, August 20, 1945, pp. 253-254.

†United Nations Interim Commission on Food and Agriculture, *Third Report to the Governments of the United Nations by the Interim Commission on Food and Agriculture*, Washington, April 25, 1945.

> which constitute a very important reserve of forest products and which must be improved by means of proper silviculture and managed efficiently in order to check serious deterioration in their composition, avoid excessive waste in their utilization, and ensure their future productivity.

It is clear that each nation must set its own forest policy, but FAO should define for forestry and forest products certain basic principles world-wide in application. In order to achieve such a world policy, it will be necessary to determine periodically both the annual productive capacity of the world's forests and the annual wood requirements of the world's peoples.

The war has created a special problem of rehabilitation of forests which have been damaged in the course of the last few years. This is particularly urgent and calls for immediate recommendations leading to remedial action.

It is equally desirable that the social problems involved be given full consideration. Measures to improve working conditions in the forests and in forest industries should be studied with the purpose of establishing a basis for general policy recommendations by FAO.

With the information now available it is believed possible to enunciate fundamental principles for a broad policy in the field of forestry and forest products ; it should deal with physical, demographic, and economic factors.

Forest Conservation.—Forest management presents essentially different aspects in different parts of the world. In temperate regions—Europe, for example—forest management no longer presents any great technical difficulties ; but there remain problems of economics, especially with regard to private forests. In many countries public action has been necessary in order to protect forests adequately against the disruptive consequences of fluctuations in supply and demand and of changing prices for forest products.

In the more newly settled countries, forest management still involves a number of technical problems which forestry research must solve. Here too, the economic factors are of great importance because the opening up of undeveloped forests usually involves a preliminary phase of extensive utilisation and crude methods of exploitation that are wholly incompatible with good forest management. In this situation both educational and administrative action is indispensable, as demonstrated by the examples of Canada, the United States and South Africa.

Even in forest stands that have not been disturbed by felling operations, the forest is often exposed to destructive agencies which can imperil its existence. These agencies are:

Forest Fires.—Forest fires cause grave losses, especially in the vast areas of resinous forests of Canada, the United States, and the U.S.S.R. Fire fighting is essentially a technical problem calling for proper equipment and well-trained specialized personnel. In addition it involves an administrative problem since the government is usually forced to assume resposibility for organising adequate fire protection and for bearing all or part of the costs of protection.

Insects and disease.—Here, additional scientific research and the development of new techniques are the prime concern.

Grazing.—In some types of forest, grazing of livestock gives a supplementary income and is not incompatible with good forest management. In other situations livestock grazing is a serious threat to forests, especially in arid countries as in some Mediterranean and sub-tropical regions where during parts of the year forests provide the only reserve of moisture and green vegetation. Forestry committee members from Greece, India, and China emphasized the seriousness of the grazing problem and stressed the necessity of educational and administrative measures in dealing with it.

Nomadic Agriculture (shifting cultivation).—In many sub-tropical and tropical regions, the people who practise shifting cultivation continue to destroy the forest in order to clear land for their primitive agriculture and then move on and destroy new areas of forest. The solution of this problem requires a broad policy involving agriculture, forestry and land utilization based on a clear classi-

fication of land best suited for agriculture and land which should in the general interest be maintained or brought under forest crops.

Forest Improvement.—In temperate countries, improvement of the forest growing stock is an inseparable part of forest management, since the large-scale introduction of new species with attendant higher yields is not entirely indispensable. However, highly intensified silviculture involving large-scale plantations and even the use of fertilizer, as well as the application of modern techniques in genetics and plant breeding has been used successfully —as demonstrated by reports from Belgium and Denmark. In equitorial regions, forest improvement is particularly important because the more valuable species are usually widely dispersed. Here silviculture should be directed towards building up forest stands composed of economically useful trees.

Here again, the technical aspect is the prime consideration, but administrative action—*e.g.*, tax reduction has also been recommended since it may encourage private forest owners to adopt measures for improving their forests.

Afforestation.—Afforestation of land suitable for agriculture and for the protection of agricultural crops can be greatly encouraged by public action. In this connection examples have been quoted from France (subsidies), Norway and certain newer countries (afforestation loan) and China, where small agricultural communities are under legal obligation to create forest nurseries and establish plantations.

Soil Conservation.—This is one of the most serious problems that foresters face because it involves not only economic consequences but the actual maintenance of populations and has a direct influence on living conditions and rural life. In this work foresters join hands with soil experts and develop programs to their mutual advantage.

War Damage.—War damage to the forests has been particularly serious in Greece, where one-fourth of the forest area has been destroyed by war operations or enemy action. To a lesser degree similiar damage has been suffered by many countries in Europe and in the Far East. This situation will call for the three following measures:

(1) Reduced cuttings in certain countries coupled with increased imports of forest products.

(2) Better utilization of forest products, especially the use of small and low grade woods previously neglected by industries and the processing of waste heretofore discarded. Such utilization has become possible through technical improvements which should now be generally introduced and applied.

(3) Afforestation on forest soils damaged by war operations. This involves treatment similar to that suggested for the denuded areas.

Forest Utilization.—Proper forest management is based on the removal of growth at periodic intervals. The harvesting of forest products should aim at securing their maximum utilization. In certain temperate countries it is estimated that only 25 per cent. of the standing tree volume is industrially used. This enormous waste is in great part due to the fact that logging operators and forest industries secrifice maximum volume utilization in order to operate at a profit. To achieve efficient forest utilization, the following should be suggested by FAO to member nations:

(1) Adoption of measures encouraging industries to make maximum use of the wood they cut.

(2) Technical education in order to make industries and other wood users realise that a higher degree of wood utilization is to their interest.

(3) Technical forest products research in specialized laboratories.

(4) Integration of forest industries to reduce waste in logging and processing.

It is stressed that research should concern itself not only with the properties of wood but also with new wood-using techniques.

Closer wood utilization is even more important in tropical and equatorial forests. Here, utilization has been mainly confined to trees of the more valuable species widely dispersed throughout the forest. This highly selective form of felling makes the whole operation very expensive and definitely limits its possibilities and leads to progressive degradation of the forest stand itself as well as reducing its economic value. Utilization of a greater number of tree species would greatly reduce production costs and make it possible for these regions to contribute more importantly to world requirements. This has not been done so far because there is a market for only a few tropical species. They are little known by the consumers and are handicapped by prohibitive transportation costs.

Where these tropical areas suffer from man-power shortage, intensive mechanization of logging operations is necessary in opening up forests. Industries must be developed within the forest itself in order to process on the spot all species and those parts of the trees which otherwise could not carry transportation charges. All these measures of mechanization and industrialization should be accompanied by the application of silvicultural methods designed to transform low grade forests into high quality stands. This might be done with a view to such definite uses as the manufacture of veneers and plywood, or the production of pulp, paper, and textiles.

Distribution of products.—In order to avoid obstructions to the orderly distribution of forest products, as well as extreme price variations, FAO should make it a major task to keep governments constantly informed concerning import requirements for and export supplies of forest products. This should be done on a world scale, and to that it might be advisable to develop further the recommendations contained in paragraph 107 of the report of the interim commission by the technical committee on forestry and forest products.

The foregoing problems or groups of problems, are basic considerations in the formation of a world forest policy. In certain respects, work towards these objectives was being conducted by a number of international organizations prior to the war. In accordance with decisions taken at this conference, FAO will carry on the activities of these organizations in so far as their purposes fall within its scope.

TWISTED FIBRE IN CONIFERS

By A.L. Griffith, D.Sc.

(*Silviculturist, Forest Research Institute, Dehra Dun*).

Knowledge of the phenomenon of twisted fibre in trees was admirably reviewed by Champion in 1925 (1). His general conclusions were:—

(1) It is a character common to all trees to produce a varying but small proportion of individuals with twisted fibre, the twist being L at first but changing to R with passage of a period of time varying greatly in length with the species. These characteristics are best developed in coniferous species.

(2) There is probably a certain amount of fluctuating variation in the direction of the fibre accounting for occassional exceptions to this general rule, others being perhaps traceable to special inhibitive influences.

(3) In areas where twist is exceptionally frequent, twisted fibre, or a tendency to produce it, is unquestionably capable of being transmitted from one tree generation to the next.

(4) Conditions found in existing forests make the inheritance of twist as an acquired character difficult to accept as a satisfactory explanation.

(1) Champion, H.G. 1925. Contributions towards a knowledge of twisted fibre in trees. *Indian For. Rec.* (Silviculture). XI (11).

(5) In such areas, a twisted variety may have originated, possibly by a simple loss mutation of a factor controlling the orientation of the growing cells. Such mutation must have originated independently in many localities, its survival, being favoured by the continued selection of the straighter trees for removal.

(6) Sound forest management on the generally accepted lines especially as regards seed-selection and thinning, should result in time in the elimination of twisted trees.

In dealing with *chir* (*Pinus longifolia*) in particular he stressed that it was a hereditary character and appeared to be largely localised in particular areas. Serveral authors such as Braun (1) and McCarthy (2) had previously noted that the twist was usually left handed in young trees and tended to straighten out or even become right handed in older trees. Braun in particular firmly established that a change in the direction of twist with age is quite usual. Champion also noted this change in the intensity of twist and even some times of the direction of the twist with age with *chir* but emphasised that right handed twist in *chir* is a phenomenon of old age and is not to be expected until the trees are some 150 to 200 years old.

Since the publication of Champion's work over 20 years ago, we in India have done comparatively little work on the effect of silviculture on twisted fibre, apart from avoiding as far as possible the use of twisted trees as mother trees in a regeneration area or as sources for seed collection.

The aspect of the effect of age on the twist has so far as I know not been followed up since Champion's investigations.

Some very interesting work on the age/twist conditions of spruce and fir in Switzerland has recently been published by Prof. Hans Burger of the Swiss Forest Research Institute in Zurich. For the benefit of readers who have not got access to Prof. Burger's work or who are unfamiliar with German (in which the Swiss forest publications are written, I give below a translation of the summary of the work.

It would appear that we should collect much more information than we possess at present on this most important subject with our own locally important species.

Burger, H. 1941.

Twisted fibre in tree species. I. Spruce (Picea excelsa). II. Silver fir (Abies pectinata). Proceedings of the Swiss Forest Research Institute, Zurich. Vol. XXII. Part I.

(Translation of Summary by A.L. Griffith)

In the appraisal of the value of wood for carpentry and for scantlings, without exception one always considers twisted fibre to be a bad fault which must as far as possible be eliminated by appropriate cultural operations. Nevertheless in order to combat this defect, it is necessary to know far more than is the situation at present, the reasons for the twisting of the fibres and the frequency of occurrence of this abnormal condition among our different species.

The works of A. Braun (1854), R. Harting (1895) and H.G. Champion (1925), have taken us some way from the starting point but still not far enough. They show that twist varies very greatly among the different species and also make us realize that it is very necessary to distinguish between the twisted fibre of young trees and that of older trees.

In this publication I mean by left hand twist (that of the "senotes" stems) the rolling of the fibres which as seen by the observer go from the right at the bottom to the left at the top of the stem. The opposite twist is that of "dextrorse" stems.

I have used a graphical method to make my comparisons. Using it, I have evaluated at different places of the Swiss plateau scattered between Thurgovie and Berne the angle of twist of the fibres of garden poles, scaffold poles,

(1) Braun, A. 1854. Uber den schiefen der polyfasem und der dadurch bewirkten drehung der Baumes. Berichte der Berliner Akademie.

(2) McCarthy, E.F. and Hoyle, V.R.J. 1918. Knot zones and spiral in Adirondack red spruce. *Jour. of Forestry.*

telegraph poles, and wood for carpentry and scantlings, some of silver fir and others of spruce. Many sawmills and timber yard impregnation plants have given me great help in this work and I am very grateful to them. My measurements and observations which are still of a tentative nature are given in the following brief review.

1. Among young spruce and fir such as garden posts of 3 to 5 cm. diameter, the twist of the fibres of far more than 90 per cent. of the stems is from right to left.

2. Twist to the left is much less frequent in scaffold poles of 10 to 16 cm. diam. We found 60 per cent. of "senotes" in the material examined. 15 per cent. had right hand twist.

3. In telegraph poles of 22 to 26 cm. diam. the pecentage again changes. In a third it is still left handed, a third has straight fibres, and a third is twisted from left to right.

4. In carpentry wood of 25 to 30 cm. diam. twist to the right was found in 40 per cent. of the cases. Among scantlings of 40 cm. thickness only about 20 per cent. are left handed while nearly half have a tendency for the fibres to be distinctly dextrorse.

5. Thus, twist in young spruce and fir is generally left handed; later the fibres are more nearly parallel to the axis, and finally after a certain age the tree tends to have a twist from left to right. Twist to the left is thus, as a general rule, a phenomenon of youth while twist to the right in conifers appears to be a sign of age.

6. Examination of the angle of twist at the foot and at the top of garden posts and telegraph poles demonstrates the interesting fact that the twist to the left is always greater at the top than at the bottom of the pieces examined.

7. With fir and spruce poles of a certain diameter the fibres are generally twisted to the right at the base of the stem, straight and parallel to the axis in the middle and twisted from right to left at the top (*c.f.* para 5 above).

8. These rules have exceptions and they are more frequent with fir than spruce. In fir the fibres are nearly always slightly wavy, so that they perforce are twisted.

9. The old coopers and shingle makers say that coniferous timber with straight fibre or slight left hand twist usually splits easily while wood with a right hand twist only splits with difficulty (*c.f.* Fanklauser). Our measurements thus indicate that the fibres of young conifers generally twist to the left. It is therefore easy to see that the stem will maintain a good capacity to spilt when the stem fibres all have the same direction of twist and even when the outside casing is made up of fibres which are straight and parallel to the axis of growth. The tendency to split will on the other hand be poor when the fibres twist to the left in the inside to the right on the outside, and still more so if the direction of twist changes several times.

10. It is thus difficult to combat this fibre twist by cultural means. At first, this defect cannot be recognised on the living tree, until at least in the majority of cases it is already too late to interfere; afterwards one is lead astray by the fact that the twist to the left of the first few years generally slowly changes for unknown reasons into a twist to the right.

11. As twisted fibres can be hereditary, it is absolutely necessary to avoid the use of trees with serious twist as mother trees or for seed collection.

12. Twisted fibre is thus a physical defect of timber which to a large degree defies remedial action by a forester.

SINGLE STEM SILVICULTURE

(Thinnings in teak crops of coppice origin)

By K. P. Sagreiya, I.F.S.

(*Divisional Forest Officer, Jubbulpore, C.P.*)

Summary.—A method of tending irregular teak crops of coppice origin is described. The crop is considered ready for the first cleaning-cum-thinning operations when the 'declared' stems have attained a height of 25 to 30 feet. All malformed shoots, interfering shrubs and bamboo regrowth are first cut back to facilitate working. After this cleaning, the best of the dominant stems, termed *elites*, are selected for retention and given the optimum growing space by felling the inferior dominant and dominated stems interfering with their crowns. By *optimum growing space* is meant a clear space round an *elite*, of radius R feet, where R is equal to the overbark, breast-height diameter of the stem in inches, *plus* 3. On the basis of this formula, the normal spacing between two adjacent stems of diameters D_1 and D_2 inches, is (D_1+D_2+6) or say S feet. A variation of ± 2 feet is permitted. When the actual distance, say X, between two adjacnt stems is equal to $(S\pm 2)$ feet these stems are considered ideally spaced and both are retained as *elites*. When X is less than $(S-2)$ feet, the stem of the smaller diameter is removed, as it is putting on lesser value increment. If the two stems are more or less equal in size, uniform spacing between retained stems is given preference over stem-quality. When X is more than $(S+2)$ feet, a *courtesy elite* is retained between the two good dominants, or else reliance is placed on coppice from the cut-back stems, to prevent abnormal development of the elites, as also to fully utilise the intervening growing space. Suppressed stems are also retained as *nurses* to clean the boles of elites. Hence the name Single Stem Silviculture.

As reliance on average espacement can easily result in unduly heavy or light retentions in an irregular crop, the average stocking density of the elites is tested in 0.1 acre check plots by the equivalent, approximate formula—

$$N=[112/(D+3)]^2$$

where N is the number of stems per acre and D is the average d. b. h. o. b. of the stems in inches.

It is claimed that with simple instructions crops can be treated in the manner indicated even by forest guards. The method is explained in detail in the form of simple instructions.

The theory involved is discussed and the 'thinings' illustrated with the help of vertical and horizontal cross sections of a typical crop (*See Page* 521). It is pointed out that in divisional practice crops cannot always be treated just when the average height of the dominant stems is 25 to 30 feet, and thereafter whenever the struggle for existence just sets in. Therefore, the N/D relationship is combined with the Age/Diameter relationship and a thinning regime on the Age/N basis evolved. As the normal number of stems per acre corresponding to a particular age is smaller the better the site-quality, and as in the Central Provinces two types of forests are generally distinguished, *viz.* the good type of forests, *i.e.*, those which are capable of producing large sized timber, called high forests, and the poor type of forests, *i.e.* those which can at best produce poles, called low forests, and further as the two types generally occur in narrow strips or small patches all over an annual coupe, and therefore tending them on different dates is not feasible, the thinning cycles for the two types have been so fixed that whenever a particular thinning is due in the *poor* type, an earlier thinning is due in the *good* type. By this manipulation entire coupes can be thinned in one operation to the desired intensity.

A thinning regime considered suitable for working plan prescriptions is given. See Table V on page 525 and page 522.

Photographs of 'good' and 'poor' quality crops before and after treatment are given. (See Plate 46 and 47).

Lastly, it is suggested that sample plots be laid out to find out if the conditions visualised in the table given above are realisable, and if so, how the performance (total value yield per acre) under the proposed single stem silviculture and the suggested thinning cycle compares with that under the orthodox methods of thinning on cycles generally considered the best.

"*The investigation of simple methods of thinning (such as spacement in proportion to girth) applicable to young crops in divisional practice, should form a subject of research.*"

—Resolution on item 10, para 4 of the Fifth All India Silvicultural Conference.

In a paper submitted to the Fifth All-India Silvicultural Conference (pp. 269 to 273 of the Proceedings) a method of thinning young plantations of teak somewhat on the lines of Heck's *Freidurchforstung* was described, and it was suggested that with certain modifications the method could be adapted for thinning irregular teak crops of coppice origin. Since then, these modifications have been worked out and several acres of crops treated accordingly, both by the writer himself, as also by foresters and forest guards under his instructions. Inspecting officers have commented favourably on the results. The method was also explained to the students of the Indian Forest College when they visited the Betul forests in 1945. An attempt is, therefore, made to describe the method,

which for want of a better name has been referred to as *single stem silviculture*, because, it aims at giving individual attention to every stem throughout its life, as opposed to the crop as a whole.

The young crops for which the method has been proposed have all come up as a result of fellings carried out in forests which contained a varying proportion of teak of all sizes and ages as also a considerable amount of suppressed advance growth of the species, come up during the life of the overwood, wherever the soil-moisture and light conditions became favourable for reproduction (*cp. Femelschlag* as applied to an intense light demander.) These fellings, variously referred to in working plan as *improvement fellings, conversion fellings modified simple coppice*, have in effect approximated to clearfellings, except for the retention of some well developed poles. The resulting crop contains a far larger. proportion of teak than the parent wood, come up as coppice from the stools of middle aged trees and cut-back suppressed seedlings because teak is an excellent coppicer and a fast growing species, which can hold its own against the adverse factors of grazing, fires and weed competition. The number of well formed coppice shoots and their vigour, as also the distribution of clumps show a very wide variation. Speaking broadly, the coppice from middle aged trees and in comparatively moister localities, such as the sheltered slopes or well drained and better stocked valleys, is the most vigorous; the latter also contains a larger number of shoots per stool. The seedling coppice is less vigorous and in the drier and understocked localities two or even three shoots on certain stools usually grow with almost equal vigour. In other words, the young crop is very irregular in form, density, stem size and composition.

'Rod' thinnings in such crops are out of the question. The usual 'grade' thinnings also cannot be carried out as crown classes cannot be differentiated. As many as 50 such coupes, of roughly 100 acres each, are annually felled in each division. The available trained staff is unable to cope up with the work of tending all these crops on the stereotyped lines. Naturally, the work done has left much to be desired from the silvicultural point of view, and crops over large areas have remained untended.

The only practicable method of treating these large areas containing a very irregular crop is to hunt out all promising stems and then to give them the optimum freedom for development, utilising for this work forest guards and even the labour gangs. This is the genesis of the method described in this note.

The method is described in the form of instructions. The theory underlying and the advantages claimed for it are discussed later.

The Method

1. Consider the crop ripe for the first cleaning-cum-thinning operations when the average height of the dominant stems over a major portion of the crop is from 25 to 30 feet.

Note.—There is no other readily ascertainable criterian, because the young crop consists of advance growth and coppice from stools of different sizes and ages inextricably mixed, varying greatly in height, diameter and distribution.

2. Cut back all climbers, shrubs and bamboos which are likely to threaten the dominant stems at a later date, as also *all* malformed coppice shoots. Collect the debris, especially the bamboos, in heaps.

3. If the crop is to be grown to eventually produce large sized timber, retain only one—the best—shoot on each stool. If, however, production of poles is the general aim, retain 2 or even 3 best shoots on as many stools as possible.

Note.—The crop now left standing will consist of only well shaped stems of various sizes, and will generally be very unevenly stocked. Thinnings, to obtain uniform spacing or in the alternative to obtain a crop of uniform size will be quite unsuitable as the former will leave larger stems standing too near one another and smaller ones too far apart, whereas the latter will leave a very unevenly stocked crop congested in some places and too open in others. To obviate these drawbacks it will be necessary to examine each stem separately and to give it the growing space needed for its optimum development.

4. Start from any well developed dominant stem and work out the optimum growing space needed by it from the formula—

$$R = D+3$$

Where R is the radius in feet, of the circle of optimum growing space round the stem, and D is the overbark breast-height diameter in inches, of the stem.

5. If within this circle of growing space there is no other stem which is likely to compete with its crown and there are stems just on the periphery of the circle, the stem will grow ideally. Therefore mark it as an *elite* and carefully prune its side branches up to a height of, say, 12 feet. Also prune such of the upper branches as are likely to promote the development of a lop-sided crown. Then go to the next nearest well-developed dominant stem, and so on.

6. If another dominant stem stands within the circle of optimum growing space, fell one of the two stems to allow the other to develop satisfactorily. As a rule, fell the smaller of the two stems as it is putting on lesser value increment. If the two stems are more or less equal in size, retain the one which will ensure more uniform stocking. Then proceed to the next nearest dominant stem.

Note.—Retain all completely suppressed stems, *i.e.*, those which are definitely overtopped, as *nurses*, to promote natural pruning of the side branches of the elites.

7. Work out the optimum spacing between the stem just examined and the one next visited from the formula—

$$S=(D_1 + D_2 + 6)$$

where S is the spacing in feet, and D_1 and D_2 are the o.b.b.h. diameters in inches of the two stems.

8. If the actual spacing, say X, is within $(S \pm 2)$ feet retain both the stems and go to the next nearest stem, and so on.

9. If the X is less than $(S - 2)$ feet. fell the smaller of the two stems. If the two stems are more or less equal in size retain the one which will give more uniform spacing and go to the next nearest stem and so on.

10. If X is more than $(S + 2)$ feet, retain both the stems as elites and, in addition, also retain an intermediate stem as a *courtesy elite* even if it is dominated or suppressed (on height basis *vide* standard definition of dominated and suppressed stems) to prevent the elites from developing lop-sided crowns. When no such intermediate stem is available reliance should be placed on coppice from the stools of the felled malformed stems. Then go to the next nearest stem, and so on.

11. After retentions of *elites* and *courtesy elites* have been carried out over, say 5 acres, check the average growing space, with the table of normal stocking (*q.v.* columns 1 and 2 of *Table II* on page 519).

Note.—This is best done by laying out at any randomly selected spot, a check plot measuring 66 ft. x 66 ft. with sides running, say NS and EW, by spacing out and making men stand at the four corners.

12. Enumerate the *elites* and *courtesy elites* lying within this check plot in one inch diameter classes and from this work out the average diameter and the number of stems per acre.

Note.—Strictly speaking stems standing inside the plot but with more than half of the horizontal projections of their crowns lying outside the plot should be *excluded*, and stems standing outside the periphery but with more than half of the horizontal projection of their crowns lying inside the plot should be *included*. But as the check is an approximate one, it will be sufficient if only the stems standing within the plot are enumerated. Stumps of cut-back malformed stems which are likely to give coppice shoots that will grow *freely* should be counted and their o.b.b.h. diameter taken as equal to the most frequent diameter of elites in the plot.

13. Work out by interpolation or by drawing a smooth curve for the normal relationship (*See Fig.* 1, page 522), the theoretical number of trees per acre for the average diameter of the stems in the check plot, say N. If the actual number is within $(N \pm N/5)$ in the elites and courtsey elites may be taken as having been given the optimum freedom for development. If not, the intensity of retention should be corrected.*

Note.—The check on *N per acre* basis has been recommended, and not on average *spacement* basis although the latter is more easily computable from the formula—$S=2(D+3)\pm 2$, because the average spacing cannot be readily guessed for a crop containing stems of various sizes.

Theoretical Consideratoins

The first tending operations have been prescribed when the 'top' height is 25 to 30 feet irrespective of the age of the crop or

*With but little practice, intelligent forest guards will be able to reserve the right stems to the requisite extent. Until such time, it is best to ask them to use coloured pieces of strings, 2 to 3 feet long, for tying round the reserved stems. These can be easily shifted from one stem to another when necessary. After thinnings have been passed and carried out the strings can be collected by the coolies and counted. Pieces of coir string dipped in a solution of *geru* (red ochre), water and sweet oil, and dried are the best.

its site quality, because observations have shown that the average height of dominant stems is the only readily ascertainable factor at this stage (crown differentiation does not become apparent till a later date), and the 'top' height is also independent of site quality up to a height of nearly 40 feet for teak. This is the stage at which *horizontal* competition amongst the 'declared' stems just begin to adversely affect their value increment, and unless given the requisite freedom the stems tend to get spindly owing to restricted crown development.

The initial cutting back of all malformed stems and other growth is advocated for the sake of convenience of working. These cleanings do not cost much and no lasting gaps in the canopy need be feared as all teak stumps in the open are bound to recoppice, and what is more important these new shoots will soon take their place in the general canopy and thus result in a better stocked crop with a higher percentage of well shaped stems. Care must however be taken to see that the stems from which a coppice is expected, are cut back at the right season and that the stools are not damaged. The ideal time to cut back is just before the sprouting season and the worst period is May-June. Exception must also be made in the case of certain desirable species other than teak, which are bad coppicers, or which are readily browsed or are slow growing such as *Pterocarpus marsupium*, *Anogeissus-latifolia*, etc.

The formula for normal stocking was arrived at in the following manner. The all India teak yield tables for plantations show (*vide* para 51 (*ii*) and table 29) that in normally stocked stands the crop diameter and the number of stems per acre are correlated and this correlation gives a more or less smooth curve which is independent of the age or site quality of the crop.* This incidental coincidence of the all-India teak tables is probably due to the fact that these tables are based on crops in which the effects of site quality and crop density were masked by under thinnings in better qualities. It is also as likely as not that some of the plots on which the all-India tables are based were not of plantation origin, but so assumed on the basis of ring counts, which merely give the age of the shoot. The rootstocks might well have been of different ages. In such crops thinnings can easily be carried out, unconsciously, on the N/D basis. There is reason to believe that this did happen in the case of certain Central Provinces plots.

Be that as it may, as the incidental coincidence, affords a rough and ready method of thinning crops, it has been adopted as the basis of the proposed single stem silviculture. Such thinnings are sometimes objected to in research practice as it is contended that if crops are thinned on the N/D basis, the spreading trees, which have a thicker bole, tend to receive larger and larger growing space at successive thinnings and *vice versa*, and thus the range of diameter variation in the crop becomes larger and larger. It is difficult to see how this can be objected to from the management point of view. If anything, as the larger trees are putting on better value increment, there will be an eventual gain in the value yield. A wider variation in the size of stems is also good for the market.

Experience has shown that whenever crops were thinned in accordance with the *crop-diameter/N per acre* relationship of the all-India teak yield tables they remained too congested. The consensus of opinion was that heavier thinnings were needed in the Central Provinces crops because:—

(*i*) They are mostly of coppice or seedling-coppice origin and their diameter development is faster because the parent stool already has well developed root system.

(*ii*) they must be opened out sufficiently to allow for a 10-yearly thinning cycle as against a 5-yearly cycle on which the yield tables are based.

(*iii*) the all-India yield tables are based on crops which must have grown under undue suppression in early life as a result of which their crown spread (and hence bole diameter) was retarded.

(*iv*) the individual tree diameters, at various ages, are much faster than those given in the all-India tables as the following data collected recently show. In all these cases, the greatest care was taken to avoid selecting trees growing in any thing but normally stocked crops.

*It is necessary to point out here that this is a mere coincidence and by no means a universal relationship for forest crops and not even for teak. For instance, Von Wulfing's yield tables for Java teak give separate N/D curves for the various site qualities. In these tables, the lower the site quality the larger is the normal N per acre for a particular crop diameter, which is what is naturally expected, because the growth of stem timber is a factor of site quality as well as crop density.

Table I—*Age versus diameter of individual teak trees in C.P. Forests.*

Age	*Crop diameter average for C.P. Forest	Individual tree diameter				
		Stem analysis				Stump analysis
		Bori	‡ Hoshangabad General	§ Amraoti	¶ Chanda	C.P. General
1	2	3	4	5	6	7
Years	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
10	2.6	..	1.5	2.6	3.1	2.0
20	3.8	..	2.9	5.6	6.0	3.0
30	4.8	..	4.3	8.2	8.3	4.0
40	5.6	8.7	5.6	9.6	9.8	6.1
50	6.4	10.7	7.0	..	11.0	8.1
60	7.4	12.6	8.3	..	..	10.3
70	8.6	14.4	9.6	..	..	12.8
80	10.0	16.0	10.8	..	..	15.0

*All-India Yield Tables ‡Coupe XII Gorakhal §Compartment 193, Sembadoh ¶Coupe IV, Kopela.

Columns 1 and 2 of the subjoined Table II give what is generally recognised as the normal N/D relationship in C.P. for a ten yearly thinning cycle in fully regenerated crops of coppice, seedling-coppice or plantation origin.

Table II.—*Normal N/D Relationship.*

Average diameter	Number of stems per acre	
	C.P. Normal	All-India Yield Tables.
1	2	3
Inches	*No.*	*No.*
2	500	900
3	350	620
4	250	440
5	200	320
6	150	240
7	125	185
8	100	145
9	90	126
10	80	105
11	70	90
12	60	80

From these figures of normal stocking a rough and ready formula for the normal N/D relationship was arrived at in the following manner. From the N per acre given in Col. 2 of the above table the corresponding average, spacing S in feet, was worked out to the nearest foot, from the triangular spacing formula.

$$S^2 = \frac{2}{\sqrt{3}} \cdot \frac{43560}{N}, \text{ i.e., } S = \sqrt{\frac{50312}{N}} \text{ approx.}$$

The results are set out in the subjoined Table III in Col. 3.

Table III.—*Normal espacement.*

Average diameter	C. P. Normal N. per acre	Corresponding spacing	Value of S=2 (D+3)	Value of N=[112/(D+3)]²
1	2	3	4	5
Inches	*No.*	*Feet*	*Feet*	*No.*
2	500	10.0	10	502
3	350	12.0	12	346
4	250	14.2	14	258
5	200	15.9	16	198
6	150	18.3	18	155
7	125	20.0	20	125
8	100	22.4	22	104
9	90	23.6	24	87
10	80	25.1	26	74
11	70	26.8	28	64
12	60	29.0	30	56

It was found that the figures of spacing thus obtained were more or less the same as those obtained from the formula—$S=2\ (D+3)$ given in column 4 of table III above. This formula was therefore used to derive the equation of the N/D curve by substituting for S, the equivalent quantity $\sqrt{50312/N}$, *viz.*, $N = [112/(D+3)]^2$, which has been adopted for checking the stocking density.*

It will readily be seen that for values of D over 9 inches the formula gives a progressively smaller value of N than what is considered normal. The divergence up to 12 inches diameter however is so small that for divisional work the formula may be safely used without any danger of overthinnings.

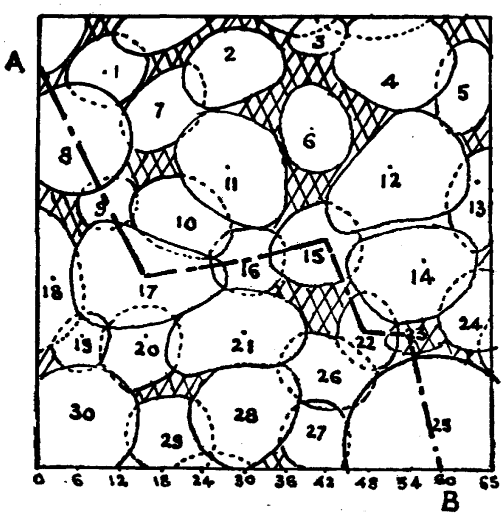
Retention of only one shoot per stool is advocated in crops which are to be grown on long rotations for producing large sized timber, because observations and experiments have shown that when more than one shoot is retained, a combined crown is developed. Individually, the retained stems have one-sided crowns and in consequence excentric boles. The total stem volume per unit of growing space occupied is more or less the same as would have been obtained on a single stem but the value yield is definitely less because there is a rapid price increment with increasing size. In the case of crops grown on shorter rotation for the production of poles, say 6 inches to 9 inches d.b.h., however, it is an advantage to leave as many as 2 or or even 3 best shoots per stool.

Example.—The 'thinnings' are illustrated in the diagrams on page 521, which show the vertical and horizontal competition in a crop standing over a 66 ft. x 66 ft. plot, before and after thinning. The particulars of individual stems and the treatment given to them are detailed in Table IV page 523. The diagram in the top left hand corner of page 521 shows the horizontal projections of the crowns before thinning, and that in the right hand corner, the optimum growing space provided to the retained stems after thinning.

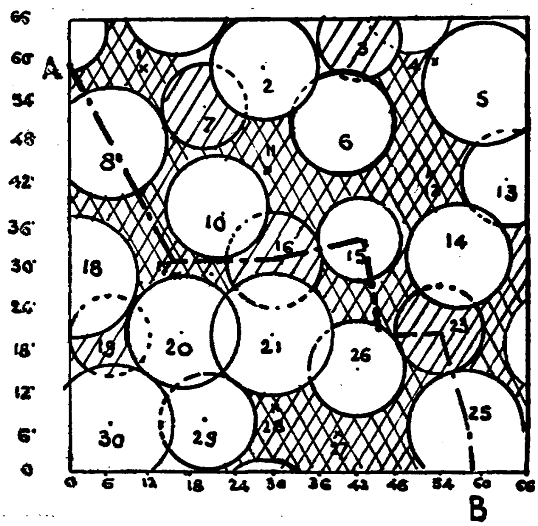
*It is interesting to note in this connexion, that Bruce and Schumacher in their *Forest Mensuration* (p. 179), suggest that the N/D relationship might be an exponential curve of the form $y = b.\ e^{ax}$ where the ordinate y represents the N per acre, the abscissa x is the crop-diameter, a and b are constants and e is the base of Napierian logarithms.

HORIZONTAL COMPETITION

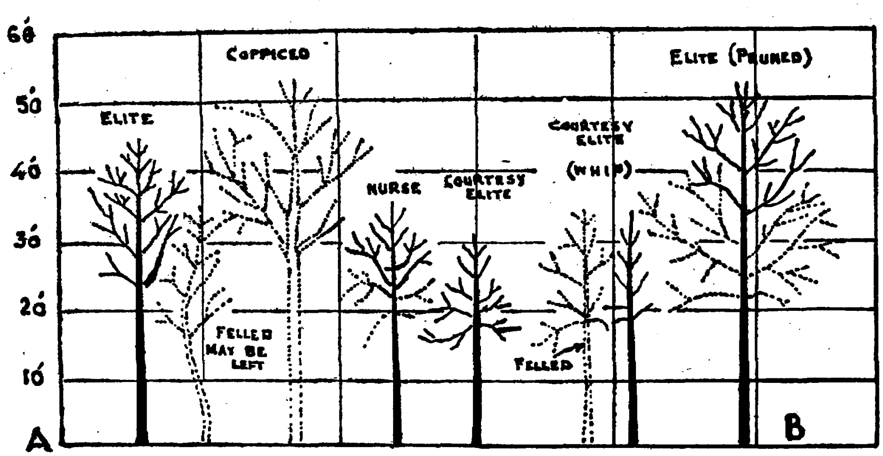
BEFORE THINNING
[Struggle for Existence]



AFTER THINNING
[Optimum Growing Space]



VERTICAL COMPETITION



Tree No.	..	8	9	17	16	15	22	23	25
Crown Class	..	D	S	W	d	d	d	L	W
Diameter	..	6″	4″	8″	4″	3″	3″	2″	8″
Height	..	46′	35′	53′	36′	32′	33′	35′	52′

HORIZONTAL AND VERTICAL COMPETITION

Before and after thinning amongst stems standing over a typical one-tenth acre plot.

Fig. 1
Optimum
Growing Space

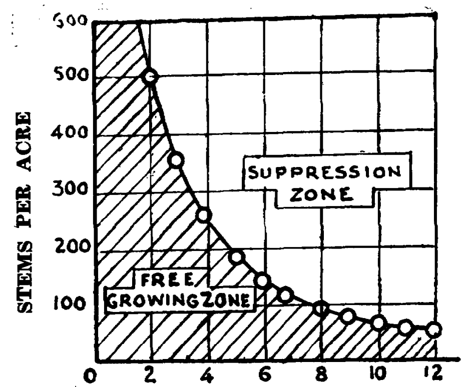


Fig. 2
Thinning Cycle & Intensity.
By Site Quality.

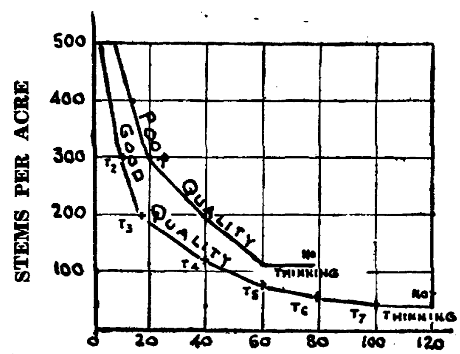
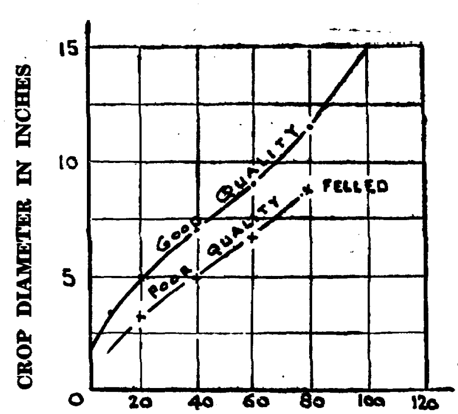


Fig. 3
Crop Diameter vs. Age
By Site Quality



OPTIMUM THINNING REGIME

Fig. 1.—Optimum growing space for all site qualities (N/D).
Fig. 2.—Thinning cycle and intensity by site qualities, 'good' & 'poor' (N/AGE).
Fig. 3.—Crop diameter and age by site qualities, 'good' & 'poor' (D/AGE).

Table IV.—*Particulars of Stem.*

Serial No.	Diameter B.H.O.B.	Opt. growing space diam.	Height.	§Crown class.	Bole quality.	Treatment.	REMARKS.
1	2	3	4	5	6	7	8
	Inches	*Feet*	*Feet*				
	3	12	30	d	Fair	.. Felled.	Interfering with 8 (elite) and a stem outside the plot towards NE.
2	5	16	42	D	Good	.. *Retained, elite.	
3	3	12	25	s	Bad	.. Retained, nurse.	To prevent lop-sided development of 2 and 6 (elites).
4	7	20	50	W	Good	.. Felled.	A 'wolf' interfering with the good dominants in its neighbourhood. Its coppice will fill the temporary gap.
5	6	18	42	d	Good	.. *Retained, elite.	
6	5	16	45	D	Fair	.. *Retained, elite.	
7	3	12	32	d	Good	.. Retained, nurse.	To side-prune, 2, 6 and 10.
8	6	18	46	D	Good	.. *Retained, elite.	
9	4	14	35	s	Fair	.. Felled.	Moribund but saleable.
10	5	16	45	d	Fair	.. Retained, courtesy elite.	To avoid a lasting gap in canopy and to ensure uniform stocking.
11	7	20	50	W	Fair	.. Felled.	Hindering development of 6, 10 and 15. Coppice will fill the temporary gap in the canopy.
12	7	20	52	W	Bad	.. *Felled.	Straight and vigorous coppice will give a future tree.
13	4	14	35	d	Fair	.. *Retained, courtesy elite.	To prevent lop-sided growth of 5, 14 and coppice of 12. In the next thinning this stem will be felled if 12 gives a good coppice but not otherwise.
14	5	16	42	D	Fair	.. *Retained, elite.	....
15	3	12	32	d	Good	.. Retained, courtesy elite.	To secure uniform stocking of the stems of the future.
16	4	14	36	d	Fair	.. Retained, nurse.	If 10 and 15 are later felled this could form an elite.
17	8	22	53	W	Fair	.. Felled.	Coppice will fill the temporary gap in canopy.
18	6	48	46	D	Good	.. *Retained, elite.	....
19	3	12	25	s	Fair	.. Retained, nurse.	Harmless and not saleable.
20	5	16	40	d	Good	.. *Retained, elite.	....
21	6	18	46	D	Good	.. *Retained, elite.	Predominant but by no means a 'wolf'.
22	3	12	33	d	Fair	.. Felled.	To allow 23 to develop a good crown.
23	2	10	35	l	Good	.. *Retained, courtesy elite.	A promising 'whip' retained to prevent the abnormal spread of 14 and 25.
24	2	10	25	d	Good	.. Felled.	....
25	8	22	52	W	Good	.. *Retained, elite.	Large spreading lower branches pruned to allow growing space to 23 and 27.
26	5	16	40	d	Good	.. *Retained, courtesy elite.	To prevent abnormal growth of 21, 23 and 25.
27	5	16	40	d	Bad	.. *Felled.	Cut-back to obtain a straight coppice which is badly needed here.
28	8	22	53	D	Fair	.. Felled.	Coppice will not be straight but will temporarily fill the gap till it is covered by 29 and the coppice from 27.
29	4	14	36	d	Fair	.. *Retained, courtesy elite.	To ensure uniform stocking and to avoid a lasting gap in canopy.
30	7	20	42	D	Good	.. *Retained, elite.	..

§D=dominant, d=dominated, s=suppressed, l=lanky (whip) and W=wolf. *Stems that will receive full overhead sunlight.

It will be seen from table 4 on page 523, that assuming that the horizontal projections of the crowns of stems from the surround that fall within the plot, counterbalance the projections of the crowns of stems of the plot that fall outside the plot (unfortunately this is not exactly the case in the illustration cited), and ignoring the space occupied by the suppressed stems Nos. 7, 16 and 19 left as nurses, and No. 23 which is a whip, but making due allowance for cut-back stems Nos. 12 and 27 which will throw out vigorous coppice shoots that will grow freely (coppice from stems Nos. 4, 11, 17 and 20 will be moribund), altogether 17 stems, elites, courtesy elites and free growing coppice, have been left after thinning, in the 0.1 acre plot, *i.e.*, 170 per acre. Their average diameter is 5.2 inches. The optimum number corresponding to this diameter is 182. This does not mean that the crop has been unduly opened out. As will be seen from the diagram, on page 522 ,some of the growing space is left unutilised by the stems of the future. Such slight waste of growing space is unavoidable in irregular crops of natural origin and in fact even in regular crops.

Optimum Thinning Cycle Working For Plan Prescriptions.

So far it has been assumed that it will be possible to carry out the first 'thinnings' as soon as the average height of the dominant stems in the crop is 25 to 30 feet, and to repeat these operations whenever the growing space provided for the stems of the future has been fully utilised and horizontal competition amongst them has again set in. This is possible only if the crops are continuously under observation and the necessary staff is available to carry out the work. Under divisional practice, where as many as 40 to 60 coupes are annually felled, this is not feasible. It is therefore necessary to modify the method to suit divisional convenience. Obviously, the most suitable thinning prescription for divisional work will be one that is based on readily ascertainable factors, such as the period that has elapsed after the last thinning and the number of stems per acre of the average size that are to be left after thinning. In other words, the thinning regime should be based on the Age/N relationship. If the crops are still to be thinned in accordance with the N/D relationship outlined in the foregoing paragraphs, it will become necessary to make due allowance for site quality variation, because for the same age the corresponding crop diameter is larger in better site qualities and *vice versa*.

Although the average site quality of the Central Provinces forests is all-India V, there is a fairly wide range of variation. On the one hand there are the forests of Bori (Hoshangabad) and Allapilli (Chanda), where, in exceptionally good stands, the crop height is as much as 90 ft. to 100 ft., on the other hand in some of the forests in Berar and Nimar the crop height is seldom more than 30 ft. to 40 ft. This apart, the transition from a better to a poorer site quality occurs with almost bewildering frequency within a small area, for instance, in an annual coupe of 80 to 100 acres the lower gentle slopes and well-stocked growth eventually attains a crop height of 50 ft. to 70 ft. whereas the steeper slopes and the plateaux carry a very open stand not capable of attaining a crop height of more then 30 feet.

It is a well established practice in C.P. to distinguish two classes of forest on the basis of their eventual crop height, namely the high forests and the low forests. By the former are meant the better quality forests worked on longer rotations of 80 to 100 years to obtain quality timber of comparatively large size, whereas by the latter are meant the average quality forests worked on shorter rotations of 30 to 40 years to obtain the maximum number of poles and firewood or charcoal.

It is therefore proposed to distinguish two types of forests, say those of C.P. site quality III and higher, *i.e.*, crops in which the dominant trees attain a height of 50 ft. or more at maturity, and those of C.P. site quality IV and lower, *i.e.*, crops in which the dominant trees attain a height of less than 50 feet at maturity. For convenience of description the former may be called *good* quality forests and the latter *poor* quality forests.

Now, if the thinning cycle on the Age/N basis is so arranged that whenever a thinning is due in a *poor* quality forest, an earlier thinning is also due in the *good* quality forest, entire coupes could be simultaneously treated to single stem silviculture.

Fig. I

Untreated

Photo: K. P. Sagreiya.

Fig. II

Cleaned

Photo: K. P. Sagreiya.

Fig. III

Thinned

Photo: K. P. Sagreiya.

SINGLE STEM SILVICULTURE IN HIGH FOREST

(Coupe VIII, Kanjitalao felling series, conversion working circle, Betul, C. P., clear-felled 1936, thinned 1945).

Fig. I.—Untreated crop. Note the profuse bamboo regrowth, vigorous but lanky teak coppice, and a comparatively higher proportion of non-teak species.

Fig. II—After cleanings, i.e., cutting back of all bamboos and malformed stems, except the more or less evergreen species not competing with teak chiefly **Saccopetalum tomentosum** and **Diospyros melanoxylon.**

Fig. III.—After single stem silviculture. Note the size variation amongst the stems and the uneven canopy which will disappear in course of time. The elites have been pruned to a height of 12 feet.

SINGLE STEM SILVICULTURE IN LOW FOREST

(Coupe II, Khora felling series, low forest working circle, Hoshangabad, C.P., clearfelled 1930, thinned 1939).

Fig. I

Photo: K. P. Sagreiya.

Before thinning. Note the understocked forest with a very high proportion of teak coppice with but few evergreen species.

Fig. II

Photo: K. P. Sagreiya.

Same after single stem silviculture. Note that as the object is the production of poles, more than one shoot per clump has been left, and as the crop is openly stocked even the elites have not been pruned. The variation in stem size and the uneven canopy can be clearly seen.

The best correlation between age, site-quality and crop diameter (hence N per acre) considering divisional convenience is given in the subjoined Table V.

Table V.—*Optimum Thinning Regime.*

Thinning	Age for site-quality		Crop Density		Crop diameter
	Good	Poor	Stems per acre	Corresponding spacing	
1	2	3	4	5	6
	Years	*Years*	*No.*	*Feet*	*Inches*
I ..	5	10	500	10	2.0
II ..	10	20	300	13	3.5
III ..	20	40	200	16	5.0
IV ..	40	60	120	20	7.0
V ..	60	(80)	80	24	9.0
VI ..	80	..	60	29	11.5
VII ..	(100)	..	40	36	15.0

For a Graphical representation of the N/D, N/Age and D/Age relationships See page 522, Figures 1, 2 and 3.

Observations in crops thinned in accordance with the proposed regime have shown that the stems retained respond admirably to it and even after the second thinning the proportion of malformed stems is very considerably reduced and practically the entire gr wing space is utilised. The retained stems also develop a well shaped crown and very clean boles due to natural pruning of lower side branches. If all lower branches are carefully pruned with sharp deep toothed saw (M-shaped is the best), quite close to the main stem, the boles become smooth even after two growing seasons.

This thinning regime and the manner in which the crops are to be treated is, therefore, recommended to the working-plan officers in place of the regimes (if they can be so called) so far prescribed.

It is not contended that this is the ideal thinning regime. The only merits claimed for it are its practicability and the fact that it will afford a standard—albeit rough and ready—by which the merits or demerits of the so called "thinnings" prescribed in the working plans could be gauged.

It is further suggested that the research branch should immediately lay out sample plots to compare the *total value yield* under the proposed regime, and those in vogue at present, and such others as are considered to give better results.

For this purpose plots may be laid out in 5 years old crops after thinning them, to save 500 best stems per acre and subjecting them to the following treatments.

Set I.

Strict Single Stem Silviculture.

To be thinned whenever horizontal competition has just set in, strictly on the normal N/D curve, *i.e.*, according to the formula:—

$S' = (D_1'' + D_2'' + 6) \pm 2.$

at intervals of not less than 5 years.

Set II.

Modified Single Stem Silviculture: diameters corresponding to particular ages.

To be thinned at the ages of the proposed regime as in Set I.

Note.—It should be noted that a crop can be thinned so as to satisfy a particular N/D curve in a variety of ways. Of these, the one which gives the maximum crop diameter and hence the lowest N per acre will give the highest total value yield. The aim under Sets I and II should therefore be to obtain the maximum crop diameter.

Set III.

Modified Single Stem Silviculture: ages corresponding to particular diameters.

To be thinned at the crop-diameters of the proposed regime to the corresponding N

per acre on the N/D curve, *i.e.*, according to to the formula—

$$N=[112/(D''+3)]2$$

taking care to give each retained stem the optimum growing space, *i.e.*, $R'=D''+3$.

Set IV.

Modified Orthodox Regime.

To be thinned at the ages of the proposed regime on orthodox lines, *i.e.*, rod thinnings or grade thinnings.

Set V.

Strict Orthodox Regime.

To be thinned at intervals and to the grades generally considered the best, *i.e.*, on current ideas regarding optimum thinning grade and thinning cycle.

It is difficult to say with any exactitude what results these sets will give but indications are that set III will show that a faster diameter increment than in the tentatively proposed regime can be obtained. In other words, a far higher total value yield per acre can be obtained from a normal forest treated to single stem silviculture than under the orthodox methods of thinning. To put it differently, if the aim is to obtain a specified annual volume yield of logs of a specified average diameter, this can be realised on a shorter felling cycle under the proposed single stem silviculture than under the tending methods in vogue at present for the extremely irregular teak forests of the province.

THE CULTIVATION OF SOME OF THE GENUS EUCALYPTUS IN THE SCRUB FORESTS OF THE NORTH-WEST FRONTIER PROVINCE

BY FAZAL GUL KHAN

(*Silviculturist, N-W.F. Province, Abbottabad*)

The war has depleted our forest resources to a great extent, conifers as well as scrub.

There was heavy demand for fuel for consumption in the cities. The Punjab could not export firewood; carriage costs were prohibitive and civil transport was curtailed to a great extent. The province had therefore to depend on its own scanty fuel resources and in consequence we have had to cut down our scrub forests.

The war is now over but our scrub forests have still to be rehabilitated. The problem naturally suggests the following questions:—

(1) Will the scrub forests coppice or have they coppiced and will the coppice ensure a fairly reasonable stocking?

(2) Will the scrub forests grow to firewood maturity in a reasonable time so as to be exploitable for the utility of the tax-payer?

(3) If not, cannot we find and introduce an exotic or indigenous species that will grow fairly quickly and with certainty and that might give a higher yield per acre and control erosion better?

The following is a short description of the items cited above:—

1. *The coppicing power of our scrub forests.* Our chief brushwood species are *sanatha* (*D. viscosa*) phulai (*Acacia modesta*) and olive, (*Olea cuspidata*) out of which the latter two coppice but the stocking of the coppice and regeneration leaves much to be desired. It is generally scattered and the soil is not well covered. Besides, the yield per acre is not enough to meet the demand from an ever-growing population.

2. *Growth rate:—Sanatha* is supposed to attain a girth of 9 inches in 20 years. Though the author of this article has not so far studied the growth period required for the exploitable girth size of olive and *phulai* for fuel production, it must be about 30 years. This means that we cannot expect much from our scrub forests for the coming 30 years.

3. Obviously then we have to devise a remedy. Have we got any indigenous quick growing species to replace the existing scrub? The answer, I think, is No. We have there-

fore as an alternative got to turn to some of the exotic *Eucalypti*, already well naturalised in the N.W.F. province.

The author will here deal with some of the *Eucalypti* which he has been cultivating from time to time in the semi-desert round Parachanar (elevation 5,500 ft. rainfall 25 inches per annum) and at Thai (elevation about 3,900 ft. and rainfall 45 inches).

Parachanar

Eucalyptus globulus, *E. ostrata* and *E. Teretecornis* were sown broadcast during the 1st week of March 1941 and 1942 over seed beds raised 6 inches above the ground; the beds were watered with a fine hose, and screened from direct sunlight, hail storms, rains and frost by wooden boards. The seed was uniformaly sown mixed with fine sand. The germination was normal and complete in from 15 to 25 days. The seedlings were placed in bottomless pots along with the wet earth round the roots when they were about 1 inch to 2 inches high. The pots were watered by percolation as usual and watering done sparsely just to keep the plants alive. In the next spring, the pot plants were planted in their permanent sites; the pits, one foot by one foot, having been prepared beforehand. Most of the plants grew well during the summer but *E. rudis* and *E. rostrata* were killed outright in the subsequent winter while about 30 percent and 40 percent of the *E. teretecornis* and *E. globulus* respectively survived the winter in the open. The survival percentage of these two species was not recorded in the subsequent winters as the author was transferred from the range but he has learnt that most of them are growing in a healthy condition. It was to be expected from the way the small seedlings survived the first winter which was a severe one. It may be noted that a few trees of *E. globulus* and *E. teretecornis* 8 to 10 years old were already growing in the station. These trees were not watered except after their first transplanting from the nursery which was done in March in all cases when the rainfall for March and April is about 4 inches in each case, followed by rains in July and August about 4 to 5 inches in each month. It is worthwhile also to note that most of the local broad-leaved species that could stand transplanting, chiefly *Platanus orientalis* could not survive without irrigation. The plantings proved that the two Eucalyptus species were better fitted for survival without irrigation at Parachanar.

THAI (Hazara)

The writer conducted similar experiments at Thai (elevation 3,900 ft., rainfall 45 inches with the said four species of *Eucalyptus* and found that *E. globulus* sowings were a failure whereas *E. teretecornis*, *E. rudis* and *E. rostrata* were successful.

The seeds were sown broadcast over well pulverised soil terraces 1 to 2 feet wide and raised 6 inches above the ground. The sowings were done on about the 25th of March 1944. No screening from hail, rain or direct sunlight was done; some of the terraces were hand-watered by a fine hose while others were not so treated. The terraces were kept weeded and by July the survival of the watered plants was only slightly better than the unwatered. It should however be noted that Hazara receives spring rains in March and April about 5 inches in each month, and slight showers in May occur followed by the regular monsoons about the 25th of June. The entire transplants were planted out in pits from the nursery at the break of the monsoons. The beds were previously watered profusely, plants lifted with trowels with the soil round the roots and the soil pressed slightly for a firmer cohesion. The balled roots were however not enclosed in straw or tied.

The survival at the end of the growing season was about 80 percent in all cases.

The experiment thus indicated that mortality from drip was insignificant in the spring as compared with similar experiments in Madras and Ceylon and the plants were strong enough to sustain drip in the monsoons.

The average height of the plant was about 2ft. at the end of the 1st growing season but shade from live hedges killed the plants when planted under or near the former. The Eucalypti are thus proved to be intolerant to shade. The experiment was not conducted in the forest. It is therefore desirable to conduct such experiments in the forest but before doing so it should be determined whether these Eucalypti form gregarious crops in a natural forest without irrigation. Many species adopt a gregarious habit under irrigation but do not necessarily do so under natural

conditions. I should think however that the subsoil at Thai is not much better than the surrounding scrub forests, the underlying rock being the same in both cases. It is also desirable to determine the range of elevation in which a given species will grow. Determination of differences between the survivals and height increments, in plantings of prolonged mossed entire transplants, stumps, patch sowings and line sowings is also desirable. The experiments are to be repeated in different stations over a number of years (say 3 years) and the conclusions drawn accordingly.

If a cheap and practical method of propagating the *Eucalypti* in our scrub forests is devised, we would be a step forward in solving our fuel problem. It should however be borne in mind that it is no use experimenting with the *Eucalypti* naturalised in our province without irrigation where the rainfall is below 20 inches or the elevation is above 6,000 ft. For areas with lower rainfall other drought resisting species of *Eucalypti* will have to be found.

Similar experiments in the past at Ootacamund solved the fuel problem in that part of the province of Madras and there is no reason why we should in the North-West Frontier province not launch similar experiments when we already know that some of the *Eucalypti* have already been naturalised in this province and can yield large quantities of seed.

ROLE OF GRASSES IN THE SOIL CONSERVATION WORK AT HOSHIARPUR

By B.K. Sahay

(Indian Forest College, Dehra Dun)

The root system of grasses has a closed collateral vascular bundle and it is of a fibrous type. The numerous root hairs are long and slender, they cover a large area and expose a considerable surface. Thus grasses with their numerous fibrous roots and root hairs are far more efficient as soil binders than most other plants.

The effect of closure to grazing resulting in protection and sprouting of grasses in anti-erosion work is of vital importance as evident in the soil conservation work in the Hoshiarpur district of the Punjab. Further it has led to an increased financial return due to sale of the grasses. The following figures give an idea of the income of the villages of the district from their sale:—

YEAR.	INCOME.
	Rs.
1939	50,000
1940	50,000
1941	60,000
1942	70,000
1943	1,10,000
1945	3,25,000 but this was mostly from *bhabbar* for paper not for fodder.

Thus there has been a continuous increase of the annual financial returns from 1939 onwards from the sale of grasses. This fact of continuous progress of the financial returns should be entertained with caution now in the post-war period when the market rates may tend to come down. It is just possible that even if the total yield of the grasses may increase with the progress of the soil conservation work, any fall in the market rates for grasses may lead to reduced financial returns. This possibility, however, should not in any way underrate the role of grasses in soil conservation work where the financial aspect must be subordinate to the pedological aspect.

The other complication which the grasses might introduce in the anti-erosion work of the Hoshiarpur district is due to its legal aspect. By a ruling of the High Court, the tenants who possess the rights to graze cattle have no right to cut grasses from the areas closed to grazing. Thus the closure to grazing is not a welcome proposition to the tenants because it restricts their rights involving serious disputes and discontent between the land owners and the tenants. Such growing tension hampers the progress of the soil conservation work. Thus cultivation of grasses involves a vital issue to be decided and agreed upon, to ensure that the proceeds are widely shared and not restricted.

In order to ensure uninterrupted progress with this soil conservation work it is essential to give immediate attention to the growing discontent of the tenants. Steps should also be taken to ensure that the set backs, if any, in financial returns should not be misinterpreted to underrate the important role of grasses in the monumental work of the district.

Note by Dr. R.M. Gorrie, Conservator of Forests, Soil Conservation Circle, Punjab

Mr. Sahay's observations are accurate and of value. The local staff are fully aware of the difficulty of grazing rights not being exchangeable into grass cutting rights, but in this matter we are bound by legal decisions and can only ameliorate hardships through practical compromise. In this the co-operative staff can help us a lot, but often the tenants are more obstructive than the landlords. For instance in Lalwan we got the *maliks* to offer unlimited grass cutting for a nominal fee; the tenants refused and eventually the court award placed them in a much worse position with only a small area open to grazing and no grass cutting concession whatever.

FOREST WEALTH OF INDIAN STATES*

Forests are an important source of the wealth of Indian states. Next to agriculture, the exploitation of forests in many states constitutes the largest industry. The extraction of various timbers, including sandalwood in which Mysore state holds the world's monopoly, and the collection of minor forest products such as fibres, resins, grasses, dyes, gums, tanning barks, bamboos, drugs and spices provide a profitable vocation to the rural population. The states are devoting much time and attention to the conservation and development of their forests. Within recent years many states have employed forest utilisation officers for research work connected with timber and other forest produce. The Mysore state has set up a forest research laboratory of its own for investigating into the possibility of utilising soft and hard woods of the state for the manufacture of a variety of articles such as bobbins, shuttles, textile accessories, matches and pencils. A few states have established forest products museums in their territories for the display of both raw materials of forest origin and of products manufactured therefrom. They have also arranged with commercial museums in big centres like Calcutta and Bombay for exhibiting samples of their forest products.

According to the latest available figures, the total area under forests in Kashmir is 10,288 square miles; in Hyderabad 9,485 square miles; in Mysore 4,422 square miles; in Gwalior 3,279 square miles; in Indore 2,624 square miles; in Bastar 2,603 square miles; in Travancore 2,402 square miles; and in Mayurbhanj 2,130 square miles. A number of other states have vast forests awaiting planned exploitation.

MAIN FOREST TYPES

There is an infinite variety in the types of forest vegetation, depending on variations of climate and soil and on other local factors. In dry tracts like those of the Rajputana states, where the average annual rainfall is less than 20 inches, forest vegetation consists mostly of the *babul* tree (*Acacia arabica*) or *kikar*. The greater part of the teak and *sal* forests are in the sub-Himalayan tract. On the south-west coast of the peninsula (Travancore and Cochin), where there is usually very heavy rainfall, the forests are of the evergreen type. Cochin forests, for instance, exhibit a splendid luxuriance of foliage and flowers and contain magnificent teak and other kinds of valuable timber. Though the normal yield of the forests is only about 6,000 tons of timber annually, the output increased to 27,130 tons in 1944-45. The littoral forests of the states occur on the sea-coast and along tidal creeks. Lastly, there are the famous hill forests of the

* Issued by the Director of Public Relations, Chamber of Princes, Council House, New Delhi.

north-western Himalaya (Kashmir state) where the vegetation varies considerably according to elevation and rainfall. On the lower levels of 2,000 ft. to 4,500 ft. the *chir* pine (*Pinus longifolia*), which is tapped for resin, is the most prominent species. Higher comes the stately deodar (*Cedrus deodara*) and above that (up to 8,000 ft.) grows the blue pine (*Pinus excelsa*). Fir woods reach an altitude of 10,000 ft., and beyond that point only birch and juniper flourish. To meet the increasing demand for fir woods, a fir working plan division has been established in the state to bring these forests under regular working plans. Willow also grows in abundance in Kashmir, and has proved suitable for the manufacture of cricket bats. There is a willow factory at Miran Sahib for the manufacture of sports goods with a branch at Srinagar. Walnut provides good material for furniture-making and wood-carving, and for the supply of rifle-butts to the Indian army. The Kashmir state forests also produce considerable quantities of resins, match woods and valuable drugs and medicinal herbs which have been fully exploited. The costus root or *kuth*, a special product of the state, is exported to China for the manufacture of incense for use in the temples. *Artemisia*, which is found in the higher and comparatively dry regions of the state, is used in a factory at Baramulla for the manufacture of santonin. Other crude drugs found in the Kashmir forests are belladonna, podophyllum, aconite and digitalis. As is well known, one of the best equipped and best staffed drug research laboratories in India is in Kashmir state.

FOREST NURSERIES

New varieties of trees are being introduced in many states. Large plantations of teak, mahogany, ebony, *shisham*, *babul*, etc., have been started in Baroda, Mysore, Cochin, Travancore, Bhopal, Indore and Junagadh. Kashmir, Jodhpur, Cooch Behar, Dewas, (J.B.), Kishangarh, Korea, Jashpur, Nabha, Kapurthala and a number of other states celebrate "Arbor Day" once a year, when an extensive campaign of planting various kinds of trees is launched. Hundreds of small nurseries are scattered over the territories of Indian states. Bikaner has opened nurseries at Ganganagar, Karanpur, Rai Singhnagar and Jetsar. Bahawalpur has started two experimental forests known as the Ghafoor forests near Lal Sunhara and Yazman.

In order to accelerate the pace of exploitation of forest wealth, Indian states have opened new roads and laid railway lines leading to important centres in the interior of forest zones. The forest tramway of Cochin is a magnificent feat of engineering. The total length of the tramway line is 50 miles. Junagadh has forest roads and cart tracks extending over a length of 314 miles.

VARIETIES OF TIMBER

Large tracts of land in Hyderabad, Mysore, Baroda, Travancore, Cochin, Cooch Behar, Mayurbhanj, Tonk, Rajpipla, Narsingarh, Sawantwadi, Bastar, Dharampur, Balsinor, Janjira, Sandur, and Pudukottai are covered with teak forests. The main species of teak forests in Baroda state are situated in the hilly tracts of Songadh, Vyara, Mahuva and Mangrol in Navsari district. In Travancore teak forests occupy the western-most belt of the main ghats, constituting the fringe of the foot hills. Considerable areas of this belt have been converted into pure teak plantations during the last quarter of a century and to-day Travancore possesses some 18,000 acres of such plantations. In the Holkar state teak has been planted in the Rampura-Bhanpura division. It is found in abundance in the valleys and low-lying slopes of the Satpura hills.

Next to teak, deodar is the most important timber found in Indian states. It occurs commonly at elevations of six to eight thousand feet. Deodar is a very large evergreen tree, its usual height being 90 to 100 feet. It grows in the Himalayan states of Kashmir, Tehri-Garhwal, Mandi, Bashahr, Suket, Sirmoor and Chamba.

Silver fir is another evergreen tree found at high altitudes in the Himalayan states. It has been found to be one of the best trees for the manufacture of wood pulp. The wood is also used in the match industry.

Chir is found in Kashmir and other Himalayan states. It is used for making boxes, and for the tapping of resin. There is a large rosin and turpentine factory at Miran Sahib in Kashmir state.

Sal is another important tree which has recently come into prominence and is com-

monly used for manufacturing railway sleepers. It is found in Hyderabad and in the eastern states of Gangpur, Keonjhar, Sonepur, Kalahandi, and Mayurbhanj. *Sal* is by far the most predominant among the various species of trees found in the forests of Mayurbhanj. The state has probably the largest continuous patch of *sal* forest in India.

SANDALWOOD

Mysore state has the monopoly of the finest species of East Indian sandalwood, seven-tenth of the world's demand being met by it. The tree grows to some extent in Coorg and some of the districts of the Madras and Bombay provinces adjoining the Mysore plateau. The wood is used for carving and as incense in religious rites and ceremonies. Oil is extracted from the wood by distillation with steam. In the Mysore factory, which is the biggest sandalwood oil manufactory in the world, the distillation is carried on continuously day and night. Two subsidiary factories have been installed at Shimoga and Bhadravati in Mysore state. Since the starting of the sandalwood industry in the state in 1916 up to 1940-41, 36,509 tons of wood have been distilled and a net revenue of over Rs. $4\frac{1}{3}$ crores has been realised. Other states producing sandalwood are Gwalior, Travancore, and Sandur. Sandalwood was formerly an important forest product in Malwa and to-day it is found growing profusely in Shajapur, Ujjain and Maundsaur districts in Gwalior.

DRUGS AND ESSENTIAL OILS

Medicinal herbs and drugs which from time immemorial have been used in the indigenous system of medicine are found in abundance in many of the Indian states' forests. Pyrethrum has recently emerged as a plant of great medicinal importance. It possesses active insecticidal properties. Started on an experimental scale in the states of Kashmir, Mysore, Mayurbhanj, Travancore and Bastar, pyrethrum cultivation has received a great fillip during the last few years. The plant was for the first time introduced in Kashmir in 1936 when a few seeds of pyrethrum were imported from Paris. Since then His Highness's government have been encouraging the cultivation of the plant. The area under pyrethrum has, during the last five years, increased from 322 acres to 2,100 acres and the sale proceeds have gone up from Rs. 3,603 to Rs. 1,84,500. The Travancore government have recently conducted the cultivation of pyrethrum on an experimental scale at Permade farm and the results show that it can be cultivated on a large scale in the state. Raw materials for the production of perfumery and essential oils are also available in Indian states. Gwalior produces large quantities of rosha grass (*Cymbopogan martini*) which is utilised for extracting palmrosa oil used in many synthetic perfumes. Lemongrass occurs abundantly in the forests of Cochin and Travancore and their is a considerable export trade in Lemongrass oil.

MINOR FOREST PRODUCE

The forests of Hyderabad, Gwalior, Jodhpur, Indore, Bikaner, Patiala, Bhopal, Ajaigarh, Akalkot, Janjira, Jhalawar, Banganapalle, Bijawar, Karauli, Kalahandi, Datia, and Surguja provide not only useful and valuable timbers but also a great variety of gums, resins, dyes and tanning materials. Some of these are important industrial raw materials and are in demand all over the world. There are some trees and shrubs that yield valuable fibres which form suitable material for manufacturing paper pulp. The Mysore state has 900 square miles of bamboo forest which forms a vast source of pulp for the paper factory at Bhadravati. Travancore has large tracts of lands under a reed locally known as "eetta". "Eetta" is common all over the forest areas in Travancore but there are two tracts over which it occurs in continuous stretches and can be conveniently worked down and utilised for the manufacture of paper and artificial silk—one in the south, within easy reach of Punalur and the other in the north, along the Periyar river and its tributaries. It has been estimated that Travancore can yield about 35,000 tons of reed annually. Mayurbhanj produces the finest quality of kusum shellac which is used for the manufacture of gramophone records, varnishes, polish, fountain pens, radio cabinets, etc.

EXTRACTS

THE GOOD EARTH

"Whoever could make two ears of corn, or two blades of grass, to grow upon a plot of ground where only one grew before would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together."—(*Swift*).

The winning of the war but opens the door of opportunity to make a better world than before. It is already all too obvious that it does not automatically produce that world but rather leaves it in desolate ruins and, worse, full of broken hearts and homes, of suffering and bitterness, of people maimed in body and distorted and disordered in mind, whether as a result of the ordeal through which they have passed or through the deliberate teaching of fanaticism. Many view the scene with cynicism and talk of the weapons to be used in the next war and of the future hostile groupings of the world. Certainly there is nothing more dangerous than easy optimism that glosses over the difficulties, and it is right to realize what terrors a future war would hold, but this realization should only stimulate us to greater positive effort. Winning the war was surely hard enough—even though in West Africa we have escaped so much of the pain and the suffering—but building a new world out of the ruins will be an even harder task and, unlike the victory of our arms, it will never be completed but must go on and on. It cannot be done by mere mass-production, for it will require not only man-power and materials, but also a new spirit in men. Founded on materialism alone, with the main objectives personal comfort; gain; security; no better world can emerge. But, while the difficulties are great, there are surely great grounds for hope in the fact so often proved that, faced by overpowering difficulties and disasters, men have again and again risen to face great odds and have won through.

But the need for a changed and better world is felt not only in countries which have been ravaged by war, but in almost every corner of the earth. This war has spread over almost the whole world, and countries that have escaped have not done so through any merit of their own, but largely through geographical position, and even they have not escaped some measure of the suffering. In these countries, however, there is not the stimulus of complete ruin and destruction, the spirit of comradeship and self-sacrifice born of suffering and difficulty, to draw the best from men. Doubtless there is a demand for progress, but progress mainly of a material kind; progress too often of the more spectacular kind. What is attained without effort is so often little valued; things received as of right mean little as compared with those for which men have been prepared to struggle and even give their lives. How the peoples of Europe have valued their

freedom, so dearly defended, and now so slowly and with such great sacrifice being won back.

There is no easy road to a better world in its truest sense, even for West Africa. Some appear to think that all that needs to be done is to set up factories all over the country, to build roads, etc., and the task is all but completed. It is good to read of possible expenditure on the development of Nigeria—amounting to £40,000,000—and to know that roads, urban water supplies, building, and—to our mind more important—education and medical services, are to be immediately extended. What may have escaped the notice of many of the general public is that the proposals of the Veterinary, Agricultural and Forest Departments have yet to be discussed.

Many appear to think that you have only to "industrialize" to bring prosperity. Industrialization may not in itself be altogether undesirable, but it is certain that it has not always brought happiness in its train—and surely prosperity without happiness is an empty thing—for though it has brought riches to some, it has often brought poverty and suffering for many, while the problem of the deadening effect of mass-production on the minds of men has become a very real one. Large schemes certainly *sound* well, but there are other things more essential to the life of man than electricity! Before the war, the most prosperous and happy countries were certainly not necessarily those most industrialized. The Scandinavian countries and Denmark seemed to be among those that had come nearest to the secret of successful living. True, there is another side to this, namely that a small nation living to itself, without world-wide responsibilities, can concentrate on its own internal welfare. But the fact remains that a country *can* be agricultural or mainly so and at the same time hold its own in the world and bring great happiness to its people.

But what is necessary is to put first things first, and surely all these things—good in themselves—will be of no avail if the essential things are forgotten. And what, of all things, appears most essential in West Africa at present? Is it not improved health? A better, happier country can only grow from the people who live in it, and cannot be imported from outside, no matter how generous the Colonial Development Fund may be. The first essential then, is that the people should become fit in body and mind. A labourer who starts his day's work with a cup full of *gari* and water, with more *gari* and water mixed in a leaf for lunch and, by way of luxury, *gari* with *hot* water at night, can hardly be expected to be very efficient in body, let alone mind. Indeed it is quite amazing what he *can* do. Only people physically fit and mentally alert can possibly respond to the many other measures for the improvement of their lives, of which the next after health, or perhaps more correctly in conjunction with health, is education. Improvement of health and education are much harder tasks than, say, making a new road or setting up a soap factory. The latter merely require competent experts, adequate labour, materials and, of course, money. These things alone are not enough to improve the health or to educate the people, for the unhealthy and uneducated are often comparatively content with their lot and do not seem specially anxious for balanced diets, nor to be free from worms, nor yet to be able to read the local press. Progress therefore, cannot at first be spectacular, and requires much patient and hard work and propaganda, using this word in its true sense.

From these things everything else follows: with improved health and better education, the demand for soap and therefore soap factories, for cocoa and therefore cocoa factories, for cloth and therefore cotton mills, for furniture and better houses, and therefore local saw-milling, and many other things besides—things not utilitarian alone, we hope, but things of beauty and things for the mind also. But there is something even more fundamental than all of these, even than improved health, for health also depends upon it, and that is the soil itself. "A rising standard of living cannot be based on a falling level of soil fertility"—so says Lord Hailey. Man has progressed extremely rapidly in other spheres—in transport, in methods of warfare, in engineering of all kinds, in medicine—but in his understanding and control of the soil he has lagged behind, and where attempts have been made to apply mass-production methods to the land, they have in well-known and oft quoted cases, brought about disaster. And so there has been a tendency to ignore the soil and all it stands for, and to go gaily on. The farmer has been regarded as old-fashioned and out of date, and in Africa, to remain a peasant

farmer is often regarded as about the lowest form of existence, compared to which even a post as office messenger is preferable. A man certainly has more honour if he can use a type-writer, however badly, than if he can merely grow a yam. Yet which of the two is doing the greater service to mankind? Even the most "bush" farmer has a knowledge of life far beyond that of many an "educated" man. He can tell at a glance what soil will grow what crop, a certain grass tells him that this ground is good for cotton, another that that is suited to guinea-corn. He is an artist too, and in Borgu farmers make yam heaps very fine. The older men take a great pride in the size of their heaps and the straightness of their lines. Anybody who thinks it easy, just try.

It is essential, therefore, to maintain and increase the fertility of our land; without that, everything else must fail, for above all, people must eat and factories are of little use without raw materials. Roads will not help if they lead to a depopulated countryside, medical treatment will avail little if the root cause of the trouble is undernourishment, and education and political development will be a hollow mockery, if the country itself is left a desert.

There is no short-cut. We have found many, especially Africans, who think that industrialization is the way out. This is false, for the factory workers must eat. "But we can export our manufactures and buy food from abroad in exchange". But who is to buy these exports? Every country wants to do the same thing—industrialize! There must be exchange among nations, and certainly self-sufficiency is (apart from war) an undesirable policy, and yet every country will have to become to quite a large degree, self-sufficient, exporting those surpluses which are required elsewhere, and importing, in exchange, those things that cannot easily be made or grown locally. "It must sooner or later be concluded that all an agricultural country has available for overseas trade are the surpluses which Nature can spare, not those which man can take. When an agricultural people attempts to barter more than this for the gawgaws of industry, it is not developing itself, but encompassing its ultimate destruction. If, therefore, an agricultural community requires for its use the products of industry, there are very real limits to the amounts which it can obtain by international trade. The new viewpoint asserts that if it requires more, its only safe method of obtaining it (if it is not to consume to-morrow's rations today) is to establish its own industries and make its own goods. Behind the tariff barriers of the modern world this is to some extent what is already going on. Necessarily, it is a policy which must increasingly prevail. This necessity is based, not on trade nor on economics as this is commonly understood, but upon man's inescapable obligation to maintain the soil of his lands or perish." (K.E. Barlow, *The Discipline of Peace*, Faber and Faber).

The development of industry has always meant a flocking of people from the country to the towns, usually with the worst possible results. In the initial stages, industry offers comparatively easy wealth, and the glamour of the town attracts. But over-crowding and unemployment usually follow. The neglected countryside fails to produce enough food and prices rise, yet nobody is better off for the value of money is purely artificial and the real wealth of the country has decreased owing to the flight from the land and resultant lowered production. "He (Man) must realize that he cannot conquer Nature—he must live with her on her own terms, making use of and conserving resources which can no longer be considered inexhaustible." (Jacks and Whyte, *The Rape of the Earth*). "This desire for cash crops to sell for machine products has been the main reason why the acts and performance of man have come to have an apparent antagonism to those of vegetation. Indirectly, therefore, it has been to feed the machine that the soil has been robbed. But the time has now come to ask whether we can continue to suppose that such an antagonism is part and parcel of the scheme of things." (K.E.Barlow).

He also says, "First things must be put first and the soil comes before the city because the city lives by the soil. Man can only carry on his own life by allowing the soil and its vegetation provide and maintain that natural endowment which is Nature's bounty......

"If we would seek out the future path of our societies, the direction in which we should turn our thoughts is not towards the machine, the minerals that lie in the bowels of the earth, and the details of trade and currency. First of all,

before any such considerations are undertaken, we must sharpen our understanding of the soil by which we live and of how Nature goes about her work of conserving the soil's fertility. We shall be better instructed by learning about the relations of species to one another and about the physiological organization of the plant and the animal than by a consideration of political boundaries and discredited economic laws."

The essential need is that sustained agriculture should keep pace with every other development. It is therefore necessary both to find ways and means of maintaining and increaing soil fertility and at the same time of making life more attractive to the peasant farmer. Barlow says, "The facts of soil erosion focus and reflect both the errors and the obligations of our way of life. They demand instant decisions upon matters which we commonly neglect. They throw into relief the present antagonism between man's way of living and the organization and performance of vegetation. They are in fact the writing on the wall. Their warning is to man's arrogance in building his behaviour upon his greed and his whims. They are the demonstration that man cannot with impunity ignore and exploit the bounty of Nature; they reveal that man's salvation can only lie in his understanding of, and co-operation with, the total performance of life.

"........What the story of soil erosion illustrates is the inadequacy of the philosophy of materialism and the notions of exploitation which accompanied it.

".......The knowledge that it is not Nature that fails but man, should afford us great comfort, for the acts of man can be amended by human resolution, whereas, while the performance of Nature can be damaged by man, its task of creating the conditions favourable to life extends far beyond his scope. We can therefore tell ourselves that the prospects of peace depend upon human understanding and human effort, upon a certain humility and a will to work tolerantly with the processes which beget our well-being. Given these, the problem of peace, although complex and unfamilar, would not appear to be insoluble.

"It is evident that industry cannot indefinitely maintain itself at the cost of agricultural methods which tear out of the land the very structure by virtue of which it remains what it is. It is evident that in the long run industry must support itself upon a two-fold base. On the one hand, it has available the surpluses which agricultural peoples can properly spare. On the other, there is a place among industrial communities, based upon an adequately nurtured and cultivated soil, for trade in industrial surpluses."

Man's problem, the world over, is that he has forgotten how to live. The means of living have become more important than life. As Barlow says, "Wonder and worship have been replaced by familiarity and a contemptuous expectation of wonders. We no longer pause before the gifts of God." The problems before us are many, but it is not so much that the problems are great as that they are not universally recognized that causes us uneasiness. Tackled courageously, by the combined efforts of all who have the welfare of the people at heart, we are convinced that even such problems as the overcrowded lands of Owerri and Calabar Provinces could be solved. But there is no room for defeatism —courage, forethought, and co-operation of all concerned, and not least, of Africans themselves are essential. There is need, too, for that humility which recognizes that man is not a supreme being to exploit the earth at will, regardless of Nature and the Power behind Nature.

That we are considering what is really practicable has already been proved in various parts of Nigeria, in settlements established for various reasons, where balanced agriculture has been practised successfully. We have in mind especially the Scottish Mission Leper Colony at Itu in Calabar Province, where palm oil is produced and processed communally: the Anchu Sleeping Sickness Settlement with its improved farming methods, pig keeping and the prospect of communal herds of cattle; and the Daudawa Settlement in Katsina Province. The war has demonstrated what can be done in the way of pig rearing and dairying; silage and the storage of fodder are but new things as yet as also is the fattening of cattle; it is reported that biltong from Nigerian factories has already greatly improved the efficiency of Sherra Leave labourers; and what of fishing and the keeping of small stock and many other things besides? While not pretending to be experts in the matter there appears to be no obvious reason why herds of tsetse-tolerant cattle should not

be kept on a much larger scale in Southern Provinces, as meat and manure producers, if not for milk, though that too might come later. The herd of dwarf cattle in Ibadan Fuel Plantations certainly seems to thrive, and produces stacks of manure for any gardeners or farmers who can be bothered to take it away. The possibilities seem endless, but too few people see them or realize their vital, their *absolutely essential* importance. If we can face such huge expenditure on roads, etc., surely we can face also the infinitely more important, though much more difficult and less spectacular task, of rehabilitating the countryside and its people. The task we contemplate is of equal or greater magnitude, and *no less essential* than that of mass education. Indeed the two are complementary for the latter must be useless without the former, and the former impossible without the latter.

Let us turn to a great agricultural authority, Sir E. John Russell. Writing in the *Geographical Review* (The American Geographical Society of New York), of "Farmers and Peasants of Europe", he says that Europe is in the main a region of small farms and the people of the occupied country wish it to remain so, for, though they recognize the economic and technical advantages of large-scale farming, they consider that the social advantages of the small farms more than make up for these; and so it is likely that the small farms will remain.

"But the small farms need not be inefficient or make heavy demand on human labour as in the old days, nor do they necessarily imply a low standard of living. The production of the protective foods needed for the high nutrition policy implied in the Hot Springs resolutions afford an admirable basis for successful small farming, as experience in Great Britain, Denmark, and the Netherlands, and other Western European countries has amply shown. Co-operation, as Denmark has proved, can give the small farmer most of the economic and scientific advantages attached to large-scale agriculture. Community settlements such as have been set up in Italy and now in Spain attempt to achieve the same end in another way, as do some of the types of settlements worked out by the Jews in Palestine. Various types of communal and Co-operative organization are available, and each nation will choose the one best suited to it: without some form of organization the small producer is at the mercy of the middleman and is liable to be hopelessly crushed. But co-operation in any form necessitates education both technical and moral: each must be both able and willing to pull his weight and to do his best for his fellows as well as for himself. And so we are driven back to the imponderable spiritual factors as the essential basis not only for the peace of Europe but even for its economic rehabilitation; they will still present the most important and most difficult of European problems after the immediate physical needs have been met."

And is it not so in Africa also? The future must be based on the proper care and understanding of the Good Earth and on the will to rise above self-interest and personal gain to a spirit of service to the community, in every sphere. Only on such foundations is there any hope for the future of West Africa.

—*Farm and Forest*, dated April—June, 1945.

PYRETHRUM CULTIVATION IN KUMAUN (UNITED PROVINCES)

T.R. Low, B.Sc. (Agri.) (London), M.C., I.A.S.
Additional Director of Agriculture, United Provinces
And
Capt. J. G. Burns
Superintendent, Government Gardens, Chaubattia

In 1943 the Government of the United Provinces were requested by the Department of Supply, Government of India, to undertake the cultivation of pyrethrum (*Chrysanthemum Cinereriaefolium*) for use as an insecticide for the army. The account which follows is a record of the attempt to cultivate this crop on a commercial scale.

Among other medicinal plants, this plant had already been tried on an experimental basis at various agricultural stations in the United Provinces, and it had been found to grow fairly satisfactorily at altitudes of not less than 5,000 ft. The trials showed that, as far as the U.P. was concerned, its cultivation would have to be confined to Kumaun, and that it was

useless to attempt to grow it in the plains. Endeavours were first made to induce the hill cultivators to undertake its cultivation, but owing to the scarcity of arable land, high prices for food crops and amount of labour involved, added to their reluctance to take up a completely unfamiliar crop, this had to be abandoned and arrangements were made to grow it on Government land under Government supervision.

In this we were fortunate as the Government Fruit Orchard, Chaubattia, situated near Ranikhet at an elevation of 6,500 ft. already had $5\frac{1}{2}$ acres under experimental pyrethrum and was able to spare an additional $6\frac{1}{2}$ acres of land which was cleared and planted up in September, 1943. To increase this area, 50 acres of standing forest, the property of the Ranikhet Cantonment was handed over in November, 1943. This was felled and cleared, the timber being utilized for building purposes and fuel and 10 acres being found suitable, was planted up.

Thus at the time of writing we have a total of 52 acres under this crop.

Conditions of Growth

As far as Kumaun is concerned the plant must be grown at an elevation of not less than 5,000 ft. in well drained soil, in an open situation and preferably in areas with a light monsoon rainfall. It will not tolerate heavy continuous rains, and is immediately affected by water-logging and a hot damp atmosphere, such as obtains in the lower valleys during the monsoon. Trial plots were laid out at different elevations and in different situations in 1943 and in all cases where the conditions were hot and humid in the monsoon, and the drainage bad, the plants failed completely. Cold in the winter season appears to have no adverse effect. During the exceptionally severe winter of 1944-1945, the plants at Chaubattia were covered for nearly a month by 2 to 3 ft. of snow but suffered no ill-effects.

Propagation

The plant can be propagated either from seed by transplanting from a nursery bed, or by splitting mature plants and planting out rooted splits direct in the field. The latter method is preferable as splits are easier to transplant and produce a flowering crop more rapidly than transplanted seedlings.

In the case of seeds, nursery beds can be sown in September and transplanted in the following March, or sown in March and transplanted in the following August-September. Seedlings are transplanted when about 6 in. high. In the same manner splits can be put down in either March or September.

In Chaubattia the best results have been obtained from transplantations carried out in March.

A well-drained seedbed is required, sowing should be thin, and the seedlings must invariably be protected from heavy rain as they are very liable to dump off. Seed is required at the rate of 1 lb. for every acre to be planted out. Germination is usually somewhat defective and the mortality among seedlings is fairly high. By far the best results have been obtained at Chaubattia with acclimatized seed descended from the original seed imported from Messers Vilmorin of Paris in 1931. In 1943, 40 lb. of seeds was obtained from the Nilgiris. These both in germination and in the subsequent vigour and yield of the mature plants were considerably inferior to the acclimatized seed.

The seedlings are set out in rows 18 in. apart with a distance of 18 in. between plants. Pyrethrum in Kumaun does not require a very rich soil but thrives best under medium to light soil conditions with good drainage. The latter is absolutely essential. No manure was given as the land was cleared forest and was in good heart, though this might be necessary in a poor soil. Afterwards cultivation consists of weeding and breaking up the soil between the plants. Intercultivation should not, however, be carried to excess otherwise owing to the steep slopes, the top soil will be washed away in the monsoon. Watering is necessary in Kumaun during hot dry weather and immediately after planting out, unless rain storms are unusually frequent.

It may be mentioned that during the time pyrethrum has been grown at Chaubattia, it has not been affected by any pest or disease. As it is a perennial plant the work has not gone far enough to make any recommendations regarding its place in a rotation.

Harvesting

The plants begin to flower in the latter half of May. The flush of flowers comes on very quickly and is all over in a fortnight. Harvest-

ing has therefore to be carried out expeditiously, if the flower-heads are not to run to seed. In October, after the close of the monsoon, a second flowering takes place, but the yield from this flush is insignificant compared to the summer flowering. To obtain the highest content of pyrethrin, the best time to pick is when half the yellow inner disc florets are open. The flower-head only is picked and none of the stalk or leaf, After picking the heads should at once be spread in a thin layer in the sun and completely dried. This is of importance as, if they are left lying about in bags or baskets, they very quickly ferment. When thoroughly dry they can, if a press is available, be baled, otherwise they should be securely packed in double gunny bags before despatch. If seed is required the best plants are allowed to ripen off until the seed is about to shed; the heads are then picked, dried, and at once packed in sealed containers.

Under Kumaun conditions the plant appears to be a perennial. Full flowering takes place in the second year after sowing and continues thereafter annually. The plant assumes a clump-like habit of growth and after four years the clumps should be lifted, split up and re-planted. The yield from two-year old plants has averaged 54 lb. dry flower-heads per acre. This is very low when compared to Kenya where the yield averages 600 to 800 lb. per acre.

Actually during 1945, 34½ mds. of dry flower-heads and 98 lb. of seeds have been produced and despatched from Chaubattia.

Pyrethrin Content

The effectiveness of pyrethrum as an insecticide depends on its pyrethrin content. The standard for commercial pyrethrum fixed by the Kenya Pyrethrum Board is a guaranteed minimum of 1.30 per cent. Japanese pyrethrum usually contains 0.6 per cent. to 1 per cent. pyrethrin.

Pyrethrin estimations have been carried out at Chaubattia with the following results:

	1943	1944
Pyrethrin I	0.877	0.700
Pyrethrin II	0.346	0.374
Total	1.233	1.074

Estimations in 1945 could not be made owing to non-availability of certain necessary chemical reagents at harvest time.

Costs

Owing to the fact that there is at present no open market for pyrethrum, all supplies being strictly controlled, and to the arrangement whereby all produce has been taken over by the Department of Supply, Government of India, on a 'no profit no loss' basis, it is difficult to give figures of receipts and expenditure.

In 1945 the cost of production of dry pyrethrum worked out at just under Re. 1 per lb. This is from crop two years old yielding at the rate of 54 lb. dry flower heads per acre.

The cost includes labour and all running expenses but excludes the cost of clearing the land, land rent and superior supervision. If these are included the cost would be very much higher.

As a comparison growers in Kenya obtained the following per lb. (reduced to Indian currency) for their produce:

1938	As.	7-6
1939	Rs.	1-3-9
1940	Rs.	1
1941	As.	10-3
1942	As.	6
1943	As.	12

The high cost of production is due to—

(a) *Low yield:*—An average of about 60 lb. per acre from crop in full bearing ill compares with 600 to 800 lb. per acre in Kenya. In Kenya the crop flowers for nine months in the year and pickings are made whenever the weather is favourable, whereas in Kumaun, there is only one short flush of flowers in May, and therefore flowering ceases till the second insignificant flush which takes place after the close of the monsoon.

(b) *High cost of cultivation:*—In Kumaun, the entire cultivation of the crop from beginning to end has to be carried out by hand labour. Owing to the small terraced fields and the very steep slopes it is not feasible to use bullocks for the preparation of the land or for after-cultivation. In the particular place where our pyrethrum was grown, as in many other parts of Kumaun, there is inadequate irrigation and hand watering of the plants had to be resorted to in the dry weather there by greatly adding to the cost. A further adverse factor is the very high cost of labour in the hills at the present time.

Conclusions

Though it has been proved that this crop can be grown under certain conditions in Kumaun the work described has been carried out purely as a war-time measure. The question arises whether pyrethrum could ever become a source of profit as a field crop to the hill cultivators in normal times. In the opinion of the writers this is not likely to be the case.

Apart from the fact that pyrthrum may be superseded in the near future by synthetic insecticides such as D.D.T. the low yields obtained, combined with the amount of labour involved in its cultivation, makes the cost of production so high that it seems unlikely that it could compete under normal circumstances with pyrethrum produced in other parts of the world or indeed in more favoured parts of India. Added to this, it is a field crop which requires to be grown on existing or potential arable land and is thus in direct competition with food crops. Arable land in Kumaun is already insufficient and even if it was a reasonable profitable crop, it is questionable whether under present food conditions in India, it would be desirable to divert arable land to its cultivation on a large scale.

—*Indian Farming,* Vol. VII, No. 2.
February 1946.

SOME INVESTIGATIONS ON THE RELATIVE TOXICITY OF BORATE AND CHLORATE AS HERBICIDES

BY A. K. DHAR, B. Sc. (AG)., M. Sc. (AG. BOT).

Department of Agronomy, Allahabad Agricultural Institute.

INTRODUCTION.

The use of chemicals for controlling weeds was recognised for the first time during the last decade of the nineteenth century and in the early part of the twentieth. Except for a few selective sprays such as the sulphates of iron and copper which were used to combat certain annual weeds growing among grain crops, and a few other chemicals such as arsenical compounds, salts and oils which were used for killing weeds along paths, driveways and roads, little progress was made in the development of chemical weed control. Bolly (4, 5), Brenchley (6—8), Aslander (1, 2) were among the pioneer investigators in this subject. It remained, however, for later investigators like Johnson (16) Offord (20) Ball, Madson and Robbins (3), Crafts (9—12), Long (13), Barnett (3), Hanson (14), and many others to look for newer developments in various phases of chemical weed control. Even fertilizers were tried to control weeds with varying degrees of success. Singh and Das (21) reported partial success in controlling *Chenopodium album* and *Anagallis arvensis* with fertilizers like ammonium sulphate, sodium nitrate, etc., applied singly or in combination. Recent researches have brought to use a few other chemicals such as borates and chlorates which also produce similar results. But recently some organic chemicals have been produced by some commercial farms in the U.S.A., one of which is trichlorophenoxy acetic acid commercially known as TCP. This is claimed to control deep-rooted perennial weeds without any harmful residual effect. Some other chemicals have also come in the Indian market, which are in the nature of hormones, claimed to have similar results.

The results so far obtained with chemical herbicides, specially, chlorates arsenites, borates, etc., have been very largely varying. Different recommendations have, therefore, been made depending largely on more or less empirical results.

Some experiments, however, have clearly indicated that the effectiveness of chemicals dependent on a number of factors—edaphic and environmental. Amongst others the condition of weather, the physical properties of soil, and the organic matter content of the soil, have been proved to be very important. As these vary from place to place, experiments were conducted at the Institute of Agricultural Research of the Benares Hindu University by the author at the suggestion of Prof. B.N. Singh

and under the supervision of Prof. K. Kumar and Mr. K. Das, to evaluate the influence of these factors, under the conditions prevailing there.

EXPERIMENTAL PROCEDURE

A pot culture experiment was designed to study the relative sterilizing effect of borate and chlorate on the farm soil. The biological method of testing toxicity was employed by growing wheat (*T. vulgare*), variety I. P. 52, as an indicator plant.

Earthen pots with diameter of 1′ at the top and 5″ at the bottom and 1′ in height, were used for the experiment. The holes at the bottom of the pots were plugged with corks and the inside of the pots were painted with a thin film of molten wax so as to avoid leaching.

The treatments were replicated five times. The pots were arranged into two series of eleven rows with five pots in each row. The total number of the pots was 110.

Soil samples were collected from the college farm. The first 6″ layer of the dry soil was taken from a ploughed field in November, 1943. The soil was pulverized to pass through a ½″ screen. The pots were filled with this soil at the rate of 20 lbs. per pot when completely air dry.

The chemicals selected for this experiment were borax (sodium-bi-borate) and potassium chlorate, as sodium chlorate which is more commonly used was not available due to war conditions.

The concentrations selected for both borate and chlorate were 0, 30, 60, 90, 120, 150, 300, 450, 600, 750 and 900 parts of dry salt per million parts of air dry soil the corresponding amounts of dry salts per pot being 0.00, 0.27, 0.54, 0.81, 1.08, 1.35, 2.70, 4.05, 5.40, 6.75 and 8.10 gms. Finely powdered salts were mixed with the soil in the pots and great care was exercised both in weighing and mixing with soil in pots.

Wheat (*T. vulgare*), variety I.P. 52, was used as the indicator plant and 15 uniform seeds were sown at uniform spacing and depth under ideal condition of soil and moisture on Nov. 15, 1943.

Watering was given every alternate day, after the seed had started germinating, with care, with a fine spray, and the water was not allowed to overflow the pots. Occasional weeding and shallow cultivation was given to pots.

The experiment was conducted for a month. The effect of the herbicides on the germination of seeds was first recorded on the 7th and then on the 15th day after sowing. The survival of the germinated plants in spite of the toxic effect exerted by the chemicals, was also taken on the 30th day after sowing. On this day the plants which still survived were carefully dug up, cleaned and washed. From each pot a plant was selected at random for recording various morphological characters such as height, number of tillers and number of green leaves. Dry weights were also recorded after drying them to a constant weight at 100°C. Only the records of germination, survival, and of dry weights are given in this paper.

EXPERIMENTAL RESULTS

A perusal of the germination record (*Table 1*) on the 7th day after sowing indicates that the germination of the indicator plants decreased singificantly as the concentration of the salts in the pots increased. In borate the germination went as low as 2.3 per cent. with 900 p.p.m. as against 86.6 per cent. in the lowest dose (30 p.p.m.) Clorate, on the other hand, inhibited germination almost completely even with 450 p.p.m.; and above this concentration no germination occurred. It was thus apparent that for equal concentration of the two, the toxic effect of chlorate was more pronounced than that of borate. When the second record of germination was taken on the 15th day after sowing, the results were almost similar.

A record of the number of plants that survived out of those which germinated, on the 30th day after sowing (*Table 2*), showed that no plants survived in chlorate series when the concentration reached beyond 150 p.p.m. per pot, but the lowest value (21.18) per cent. recorded for borate was found to be equivalent to 900 p.p.m. of borate. Thus when some plants survived even with 900 p.p.m. of borate no survival occurred beyond 150 p.p.m. of chlorate.

The growth of plants as indicated by the height, number of leaves, number of tillers also showed similar results. However, an interest-

ing result was obtained when borate was applied in smaller doses, namely, 30, 60 and 90 p.p.m. It was observed that the height, number of tillers, etc., increased up to the application of 90 p.p.m. of borate which became equal with the control in the still higher doses and then gradually decreased as the doses were further increased.

The effect on dry weights were also similar. All applications of chlorate even in the lowest dose immediately depressed the dry weight and this became more pronounced as the concentration increased.

Borate, on the other hand, showed an increase in dry weight with lower doses; the maximum being noted against 120 and 150 p.p.m. after which the curve began to fall.

TABLE 1

Showing the relative toxicity of borate and chlorate on germination of the indicator plants, on the 7th day after sowing.

Concentration in parts per million	Borate		Chlorate	
	No. of plants germinated (average of 5 pots)	Percentage germination	No. of plants germinated (average of 5 pots)	Percentage germination
Control 0	13.2	88.0	13.4	89.3
30	13.0	86.6	9.4	63.2
60	12.0	80.0	5.0	33.3
90	11.2	74.6	3.8	25.3
120	10.4	69.0	3.6	24.0
150	9.4	62.6	1.8	12.0
300	7.4	49.3	1.6	10.6
450	6.2	41.3	0.2	1.3
600	3.8	25.3	0.0	0.0
750	2.2	14.6	0.0	0.0
900	0.8	5.3	0.0	0.0

The critical difference for borate-treated plants obtained on analysis was 2.02 plants and that for chlorate was 6.03, on a 5 per cent. level of significance.

TABLE 2

Showing the relative toxicity of borate and chlorate by the survival of the indicator plants, 30 days after sowing.

Concentration in p.p.m.	Borate		Chlorate	
	Number of plants survived (average of 5 pots)	Percentage survival of the total germination	Number of plants survived (average of 5 pots)	Percentage survival of the total germination
Control 0	12.0	32.4	12.2	92.4
30	10.8	83.0	6.8	72.3
60	9.2	73.3	3.4	48.5
90	9.6	80.0	2.8	45.1
120	8.6	79.0	1.2	24.0
150	7.8	74.5	0.0	0.0
300	6.2	60.0	0.0	0.0
450	5.6	70.0	0.0	0.0
600	2.0	38.4	0.0	0.0
750	1.2	26.6	0.0	0.0
900	0.6	21.1	0.0	0.0

The critical difference for borate-treated and chlorate-treated plants was 2.87 and 2.11 plants respectively.

TABLE 3

Showing the relative toxicity of borate and chlorate by the dry weight of the survived plants, 30 days after sowing.

Concentration in p. p. m.		Borate	Chlorate
		Weight in gms. per plant average of 5 plants.	Weight in gms. per plant average of 5 plants.
Contro	0	0.155	0.196
	30	0.240	0.088
	60	0.261	0.071
	90	0.267	0.043
	120	0.352	0.018
	150	0.355	0.000
	300	0.268	0.000
	450	0.201	0.000
	600	0.197	0.000
	750	0.148	0.000
	900	0.060	0.000

The critical difference for borate and chlorate-treated plants was 0.018 and 0.021 respectively.

Experiments were also conducted to study the residual effect of the application of borate and chlorate. The results were almost similar and it was observed the toxic effect remained in the soil for quite a long time.

The effect of organic matter in reducing the toxicity was also studied. The results indicated that organic matter reduced the toxicity when lower concentrations of chlorate salt were used but with higher concentrations the effect was not appreciable.

DISCUSSION

A comparison of the relative effectiveness of borate and chlorate which were studied in the experiment reveals that chlorate is much more toxic than borate.

Germination was adversely affected by both the salts, and the higher the concentration the fewer the plants that germinated. The concentrations not only affected the total germination but also influenced the length of the time required for germination. This higher concentration not only lowered the germination but also delayed it. A differential effect is, however, observed between the effects of the two, chlorate proving more toxic than borate.

Thus when records of germination, surviva and morphological characteristics of the plants grown with these salts were studied, the conclusion was that chlorate proved to be definitely superior to borate in toxicity. It appears that the oxidising capacity of chlorate plays a more significant role than the direct toxic effect of the elemental boron in borax.

It is, however, of interest to mention that the present experiment with borate indicates that this chemical has not been as effective here as was shown by the results obtained by Craft (11) in his extensive studies with several types of Californian soils. He reported that with Fresno sandy loam complete killing of the plants was found with 140 p.p.m. of borax, but with Stockton adobe clay it took 680 p.p.m. of borax to kill the plants completely,

within one month. Other investigators like Haselhoff (15), Geigel (13), Johnston Dore (17, 18), Warrington (22) and many others obtained this result even with lower concentrations with boron. It was, however, accepted that pure boron is more effective even with lower concentrations than borax which has got only a smaller amount of boron in it, which is responsible for the killing of the plants.

Crafts (12), however, used borax as was used in this experiment. The difference in the results may, however, be explained by recognising that different plants can tolerate different amounts of boron. It may be possible that the indicator plant used in this experiment had greater capacity for resistance than the Kanota oat plant which were used by Crafts as indicator plants. The toxicity was also different on different kinds of soil, hence the soils used here might have been of different types from those used by Crafts. The purity of salt might also have influenced the result.

SUMMARY AND CONCLUSION

A comparative study of potassium chlorate and borax as herbicides indicated that both the salts in higher concentrations effected germination. The herbicides not only decreased the germination but delayed it also. It was observed that chlorate salt was more effective in reducing germination than borate.

The result obtained indicates that chlorate salt even with a very low concentration (120 p. p. m.) is very effective in killing and destroying all plants within a very short time. Borate, however, requires a much larger concentration for the same result to be obtained and may not be even very effective or economical.

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—*The Allahabad Farmer*, Vol. XIX, No. 6, dated November, 1945.

NATIONAL PARKS ASSOCIATION

DEVEREUX BUTCHER

Executive Secretary, National Parks Association, Washington, D. C.

The world's most spectacular achievement in nature and wilderness preservation had its beginning in this country in 1872. In that year Yellowstone National Primeval Park was established. Since that time, over twenty other great primitive parks, as well as a number of national monuments, have been established. To manage this system of reservations, to guard its wildlife, plant life, and other natural features, and to provide for its enjoyment by the public, the National Park Service was established in 1916.

Many people erroneously believe that the national primeval parks and monuments have remained and will always remain inviolate. However, selfish interests frequently have bills introduced in Congress in an attempt to make it legal to graze livestock, cut timber, develop mines, dam rivers for water power and irrigation, build needless roads, and introduce artificial amusments within the parks. Such activities defeat the purpose for which the parks have been created—namely, to permit this and future generations to come into contact with pristine nature for the recreation, inspiration, education, and spiritual uplift that such contact brings.

It is sometimes possible for an organized small minority proposing commercial invasion of these reservations to have its way over a vast, but unorganized, majority. Thus it is that a power dam built in 1913 floods the once beautiful Hetch Hetchy Valley in Yosemite National Primeval Park ; and that during World War I certain flower-filled alpine meadows in the parks were opened to the destructive grazing of livestock.

Other threats to the national primeval park system are the inclusion of areas that contain important resources that will be needed for future economic use, or which lack the high standards of the world-famous national primeval parks.

It was for the purpose of defending the parks against all such desecrating influences that the National Parks Association was established in 1919. It is the work of the association to promote the preservation of primeval conditions in the national parks, and certain national monuments, and to maintain the high standards of the national parks adopted at the creation of the National Park Service. It is the work of the association also, to help preserve wild and wilderness country and its virgin forests, plant life and wildlife elsewhere in the nation wherever there are areas of national importance still needing protection.

Noteworthy among such areas at the present time, for which the association is urging protection, is the proposed Everglades National Primeval Park in Florida. In other categories are: (1) the Grandfather Mountain area in North Carolina proposed for addition to the Blue Ridge Parkway; (2) the proposed Grasslands National Monument in Nebraska and South Dakota to preserve a substantial sample of the original plains country and its fauna and flora; (3) protection of one of the few remaining groves of royal palms located outside the suggested boundaries of the proposed Everglades National Primeval Park; and (4) protection of a stand of fan palms not yet included within the protective boundaries of Joshua Tree National Monument in California's Mojave Desert.

The association is also interested in the establishment of new suitably located national parkways, such as the Blue Ridge Parkway and the one now proposed for the Mississippi Valley, these parkways to be free of all unsightly developments, and with natural vegetation and landscape restored and protected.

The early establishment of the Quetico-Superilor lakeland in Minnesota and Ontario as an international wilderness area, to be administered on the United States side by the U.S. Forest Service, is one of the important projects of the assocation. A new threat has lately arisen to desecrate the Superior roadless area, and the association is now closely watching all developments pertaining thereto.

Preservation of nature in foreign countries through the establishment of national parks and similar reservations has the association's endorsement and support. In this connection, the passage by Congress of an enabling act to put into effect the Pan-American Treaty for Nature Protection is urged by the association.

To carry out its work, the association publishes the beautifully illustrated *National Parks Magazine* presenting articles on critical matters relating to the national primeval parks and other wilderness and nature reservations. The magazine also contains articles on adventure, natural history, and human interest that pertain to our great scenic and wilderness country, as well as a review of current legislation relating to the national parks and monuments. The magazine has a growing distribution to individuals, allied organizations, schools, universities, and public libraries.

At irregular intervals the association issues newspaper releases that are designed for public enlightenment; and on matters of emergency, releases are issued to members and to allied organizations.

Through the more than quarter-century during which the National Parks Association has defended the national primeval park system and the national policy governing it, the most persistent threat has been that of the hydroelectric and irrigation interests.

As early as 1920, the association opposed a project to use commercially the waters of Yellowstone Lake by construction of a dam at its outlet. This same threat continues to arise periodically.

The association has fought against plans for both a reservoir and a road in the wilderness southwest corner of the Yellowstone.

Other plans for the commercial use of park waters have included one in Glacier National Primeval Park.

In 1928 the association participated on the Joint Committee on Recreational Survey of Federal Lands set up by the National Conference on Outdoor Recreation called by President Coolidge.

The association has worked for the establishment of several national primeval parks such as Great Smoky Mountains in North Carolina and Tennessee, Acadia in Maine, Big Bend in Texas, and Olympic in Washington.

In 1931 a special committee of the association made a survey of the features of the proposed Everglades National Primeval Park in Florida. Reporting favorably to Congress upon the project, the association has been promoting the park's establishment since that time.

The association has worked toward the protection of other wilderness areas, such as the Porcupine Mountains in Michigan, which was established as a state park in 1944; and it has helped to guard the Adirondack wilderness in New York, which has been, and is again today, threatened with logging and hydroelectric development.

Because areas of inferior quality, when brought into the national primeval park system, tend to dilute the quality of that system and make the defense of the great parks more difficult, the association has fought against such introductions. Among these have been the proposed Mescallero and Ouachita national parks, both of which were successfully prevented from being established.

To overcome public confusion as to the purpose and function of the great parks and to help prevent political assaults upon them, the association has long advocated as an appropriate designation for these reservations the term *national primeval parks.* Recently, a special committee of the association has re-examined the national park standards as formulated twenty-two years ago by the Camp Fire Club of America, and has just completed their revision. This revision has been published by the association, and it is available in attractive reprint form, under the more fitting title, National Primeval Park Standards.

The association recognizes the many dangers facing the preservation of our priceless nature and wilderness reservations during this postwar period. Commercial development is necessary, but it need not and must not conflict with wilderness reservation. Threats exist in ill-advised schemes for construction of superhighways, airplane landing fields, increased use of airplanes, resort development, and in many proposals for hydroelectric power and irrigation projects.

As our population grows, so grows the human need for wilderness. That this nation may not be made poorer through loss of the last remnants of primeval country, the National Parks Association is calling upon interested persons everywhere to keep in touch with the association, both for the purpose of informing it and keeping informed by it. Only through such united effort and vigilance can we defend our superb nature reservations for ourselves and future generations.

—*Journal of Forestry*, Vol. 44, No. 3, March 1946.

VOLUME 72 NUMBER 12

INDIAN FORESTER

DECEMBER, 1946

GRAZING MANAGEMENT AND IMPROVEMENT IN MADRAS PROVINCE *

By J. A. Wilson

(*District Forest Officer, Wynaad, Madras.*)

At the time I wrote my note for the silvicultural conference of 1939, it had of necessity to be brief, as the whole question of grazing policy was under review, a special officer having been appointed for the purpose towards the end of 1938.

The special officer's report reviewed the history of forest grazing in part I and in part II made various proposals for a revision of policy.

A brief precis of the suggestions made is given, as I do not think they have had the publicity that was given for example to the Bombay proposals.

1. *Basic Policy.*—An elected government which in the first place desired the whole question of forest grazing to be reviewed had indicated that they wished to check a policy which had tended toward the indiscriminate utilization of forest grazing grounds, and to substitute in its place a policy of regulation that would result in improvement instead of deterioration.

The recommendations made were:

(*a*) The object of reserved forests over a great part of Madras was the provision of produce (including grazing) in local demand.
(*b*) The forests should be worked primarily in the interests of the villager.
(*c*) Generally speaking forests on the plains were to be worked for fuel and fodder, and those on the hills as high forest, though detailed treatment would naturally vary in many cases.
(*d*) Essential cattle for domestic and agricultural purposes should have preference over surplus animals.
(*e*) Measures should be taken to improve and protect grazing grounds.
(*f*) Control and improvement involved expenditure and it was reasonable that this expenditure should be recovered from those who would reap the benefit.
(*g*) Forests were a national property and ordinarily the national interest should not be subordinated to the local interest.

In order to put this policy into effect it was suggested that the previous classification of reserved forests into:

(*a*) Provincial remunerative (valuable timber and fuel forests),
(*b*) Provincial unremunerative (climatic forests),
(*c*) Local or *ryots* forests

should be changed as it had little result in practice.

It was recommended that all forests could conveniently be classified under two heads.

(*a*) Major forests—areas in which forest grazing is to be subordinated to the principles of sound silviculture and forest conservation.
(*b*) Minor forests—areas in which the provision of grazing must rank *pari passu* with other objects of management.

2. *Regulation of grazing.*—An elected government had expressed themselves in favour of the introduction of the block system with limitation of numbers where necessary, preference to be given to local cattle.

The proposals made were:

(*a*) To reintroduce the old block system in all minor forests with limitation of numbers admitted, priority of admission being in the order essential, local, others, up to the carrying capacity. Blocks to be about 5,000 acres. Rigidity to be avoided by allowing cattle licensed for any particular block to trespass into the adjoining blocks without penalty, thus making the system one of overlapping blocks.
(*b*) To introduce a system of special blocks with the object of working areas of good grazing near villages intensively on a rotational basis so as to prevent deterioration and to offer exceptional grazing to better quality animals. The expressed intention was to include in such blocks fuel coupes which had enjoyed a period of closure and which therefore carried good pasture.

* Paper presented at the 7th Silvicultural Conference (1946), Dehra Dun, on item 8—Forest Grazing.

(c) To introduce a penning block system in the major forests where conditions were suitable, in order to accommodate surplus animals excluded from the marginal blocks, and a certain number of migratory cattle which have always visited such forests at certain seasons. Each block to consist of a "home" pen with grazing pens surrounding it, worked rotationally. Pen hygiene to receive attention by disposal of manure either by sale or otherwise. Number of cattle admitted to each pen to be limited to the carrying capacity.

3. *Determination of essential cattle.*—The recommendation was that land held should be the basis for calculations. This question was discussed in the provincial fodder and grazing committee which recommended that essential cattle should be on the scale:

Area of holding	*Essential cattle allowed*
Up to 2 acres.	2 units
2 to 5	3 units
5 to 10	4 units

and 1 extra unit for each additional 5 acres.

Other matters connected with forest grazing were dealt with at government's specific request.

1. *'Local' and 'Foreign' cattle.*—In various divisions *foreign* cattle had as a general principle paid higher grazing fees than *local* cattle, but there was no uniformity in the method of distinction between the one and the other. It had also been suggested that cattle kept for trade purposes and those kept for agricultural purposes should be distinguished and that the former should pay higher grazing fees. The recommendation was that sound policy demanded that the aim should be to make the best facilities available to the best cattle and so encourage improvement and that therefore the term *foreign* should be applied only to cattle from areas outside the province. All cattle from within the province would be considered on an equal basis except for the measures of preference already suggested for local cattle under the local block and special block Systems.

(2) *The cattle and dairy industry in India.*—(Dr. Wright's report).

The subject of improvement of fodder supplies in the light of the recommendations made in this report was considered. The suggestions made were:

(a) The development of the special block system with its, intensive management and possibly the introduction of manurial treatments in such blocks.

(b) Develop agri-forestry or *taungya* introducing good species of grasses.

(c) Develop hay making, silage making, or the manufacture of dried grass as hot weather fodder reserves.

(3) *Rotational grazing.*—The recommendations made were that the rotational principle should be applied in the special block and penning block systems.

(4) *Artificial introduction of grasses.*—The problem set by government was to co-ordinate the work of introduction of the most suitable species of grass with the work done in the agricultural department.

The recommendations made were to concentrate on four species considered to be of outstanding value in Madras pastures:

(a) *Heteropogon contortus*

(b) *Cenchrus ciliaris*

(c) *Sehima nervosum*

(d) *Iseilema laxum*,

and to introduce these in areas regenerated by agri-forestry. Further to investigate the possibility of increasing leguminous fodder plants in forest grazing grounds was desirable as was also an increased knowledge of hardy species of grasses found in natural pastures.

(5) *Improvement of water supplies in grazing grounds.*—The recommendations were that existing sources should be maintained and improved with the co-operation of the local people, and that new sources should be developed in the more remote forests so as to improve penning facilities in such areas.

(6) *Erosion and its control.*—The suggestions made were to complete an erosion survey through district committees, to establish a soil conservation advisory council for the province and a publicity campaign to focus public attention on the subject.

Finally a research programme was put forward under the heads soils, nutrition, pastures, live fences, penning facilities, and hot weather fodder supplies. This programme was kept simple in the extreme, the object being to gain sufficient indications for future experiments to be laid out on correct scientific lines.

The recommendations received the general approval of government and the portion of the research scheme relating to pasture research, live fences and hot weather fodder supplies was approved and ordered to be taken up. The portion relating to soil and nutrition research was merged with a similar item in the agricultural department programme. Though these proposals were put forward in June 1939, final orders were passed only in August 1942 by which time the war crisis was at its height.

After completion of my term as special officer, I was directed to apply the principles put forward in the report to the North Coimbatore forest division and to put into effect the portion of the research programme sanctioned. The following is a general note of results in that division:

1. Reclassification of forests

Reclassification of forests was done without particular difficulty the line of division running generally along the top of the ghats, allocating the outer slopes and terai to minor forests and the hills to major.

2. Regulation of grazing

(*a*) The reintroduction of the block system, which required a grazing settlement for each village was found impracticable due to war conditions which rendered it quite impossible to get necessary statistics from the revenue department. The division into blocks was completed, the capacities allocated, and once conditions return to normal there should not be much difficulty in working out the details. Once this is done and orders given effect to it will take time and patience to overcome the various practical difficulties and make necessary adjustments. Much will depend on the attitude adopted by the elected government which has come into being, and which will have a great influence on its followers. From my brief association with the previous elected government I found them very keen to apply sound principles of grazing management and this augers well for the future.

(*b*) The introduction of the special block system met with great success. Starting in 1940 the areas placed under intensive grazing management totalled 2,297 acres distributed over 10 blocks.

The conference may be interested in the details of working of the system, which provides for a type of control that has generally been criticised as being on too small a scale and impracticable under forest conditions.

Blocks were selected with reference to villages and provided conveniently for classes of animals that do not frequent forest grazing grounds except in the off-season. I refer to milch cattle and plough bulls.

In each case the same procedure was followed. First a meeting was held with the villagers, starting with a general discussion on forest grazing and bringing out criticisms by the villagers themselves. Gradually the discussion was brought round to the new ideas which were suggested, but not proposed to be enforced unless they agreed. It was pointed out that in general the pastures were deteriorating and furnishing less fodder than previously (always accepted unanimously). Next that closed coupes invariably recovered under protection and deteriorated fast once reopened, as all animals concentrated on them (again always accepted). The necessity for other products apart from grazing was emphasized, particularly fuel and bamboos, and this made closures unavoidable since, if grazing were unrestricted, cattle invariably developed into browsers, and young crops could not grow (again always accepted). As regards the cattle, though they were increasing in numbers, improvement was confined to the utility cattle, which rarely visited the pastures as there were only a few hours available to them for grazing, and association with scrub herds was a bad policy in any case. As regards the scrub herds these were criticised on stereotyped lines.

The bait was then offered. If the number of cattle could be limited to what a newly opened coupe could carry, everyone would benefit. The cattle would get a full meal and the damage to the tree crop would be stopped. Instead of a 5 year closure it would be possible to reduce to 3 years, a reduction of nearly half. This usually stimulated interest, and the scheme was explained. Coupes were adopted as paddocks and it was usually possible to get groups of 3, one newly opened but not yet spoiled, the other two to be opened under the reduction of closure. The number of cattle for each group (block hereafter) was determined on an eye estimate and usually varied from 2½ to 3 acres per cow

unit. Movement was elastic, according to the condition of the pasture and the number of paddocks. This was regulated as below:

2 paddocks. Graze alternately 1 month with 1 month rest.

3 and 4 paddocks. Graze a minimum of 2 weeks and a maximum of 1 month. Within these limits cattle could be moved as the grazier wished provided that he notified the beat guard, and gave a paddock 1 month's rest once it had been grazed.

5 paddocks. As for 3 and 4 paddocks except that the minimum period was reduced to 1 week.

Grazing was limited to one paddock at a time, and the removal of manure or carrying of knives by graziers was forbidden.

The responsibility for seeing that these restrictions was observed was on the beat guard who maintained a schedule of movement available for inspection by range officers or the district forest officer at any time. Movement was therefore susceptible to check.

The proposals were then put to the meeting and there was usually an argument between progressives who were for acceptance and the conservatives who usually owned the large scrub herds. In general the reception was favourable and a trial was agreed to. Finally came the sting. We were offering good grazing. It was worth an additional grazing fee. Moreover, unless this was charged all owners would want to come in with all their cattle, and those to whom permission was granted to avail of these benefits would have little right to keep others out, as they were getting something for nothing. If an extra fee were paid, it would convey a specific right, and those who had paid would see to it that others got no benefit.

To cut a long story short, persuasion gained the day and the system was introduced and extended. Extra fees were paid amounting to 2 to 3 times the normal fee of 0-4-0 per head per annum in addition to that fee. It was worked under me for 5 years when I was transferred. Having introduced it I was naturally interested in seeing results and my experience has been very encouraging. The standard of cattle using these blocks is distinctly better than scrub and a large number of working bulls and milch cattle gain the advantage of pasturage. The pastures have not deteriorated while the tree crop has progressed with very little damage from browsing. During my inspections cattle were usually found with their heads down and in the few cases where browsing was suspected, close investigation usually showed that the animal was eating a creeper. Often I have found cattle lying down on a full stomach. During the 5 years additional revenue of over Rs. 5,000 has accrued in addition to the normal grazing fees. The proposals for 1946-47 cover a total of 23 blocks of 7,000 acres and forecast an additional revenue of Rs. 1,650.

I feel therefore that a just claim to progress on more than an experimental scale can be made.

3. Developments of agri-forestry or taungya

Experiments have shown that the growth of ~~the~~ species with field crops is possible, and in some cases their growth is spectacular. Cultivation of field crops is for 3 years. With the last year's field crop it has been found possible to introduce *Cenchrus ciliaris.*

This is sown by the cultivator with his field crop usually *Pennisetum typhoideum* with a light mixture of the legume *Phaseolus aconitifolius* in the proportion 25 lb. grass seed: 9 lb. *Kambu* (*bajra*): 2 lb. of *Phaseolus.*

The tree crop is in lin s 15 ft. apart and the species in random mixture consist of *Acacias, Planifrons, sundra, leucophloea* and *ferruginea, Albizzias lebbek* and *amara, Azadirachta indica, Zizyphus jujuba,* and *Prosopis juliflora.*

Leys so raised have been leased for grazing at a rate of Re. 1 per head per month, and the maximum revenue realized by such leases has been Rs. 5 per acre per annum. So far as the method goes, there seems to be nothing inherently wrong with it, and our difficulty has been to get the cultivators. The annual rainfall on the areas worked was 25 to 30 inches.

4. Hot weather fodder supplies

Silage.—During each of the years 1940-44, silage was made successfully in pits 25 ft. × 12 ft. × 6 ft. in forest areas from natural grasses cut from closed coupes, chiefly *Heteropogon contortus, Amphilophis pertusa, Eragrostis bifaria,* and *Chrysopogon montanus.* Costs were higher than one had been led to believe at about Rs. 15 per ton taking the labour rate at 8 annas per adult male. This is easy to understand. The grasses are interspersed

with the tree crop and are therefore suitable for cutting only in patches. Moreover, within the patches the species do not ripen at the same time, and this factor is more pronounced when certain species such as *Heteropogon* reach the young milk stage at which they must be cut to avoid the awns. I found it necessary to cut 200 acres of jungle to fill one pit. My opinion therefore is that silage made in forest areas must be of high quality to justify the expense, and once prepared must be fed as a concentrate and not as a bulk fodder. Mixture with hay proved very satisfactory and the silage seemed to impart an extra attraction to the hay. A complication that arises in respect of widespread preparation of silage in forest areas is that unless fed fairly fresh from the pit it dries out quickly. It is essential therefore that pits be accessible and close to centres of consumption. This limits the areas that can be tapped. That the local cultivators saw and appreciated what was being done on an experimental scale is amply shown by the fact that a complete pit surplus to requirements was sold for Rs. 75 (end of 1944).

No attempt was made to improve the silage by the addition of molasses or the like.

In passing I might mention that the inclusion of such grasses as *Cymbopogon caesius* and *Flexuosus* which produce a large quantity of herbage in comparison with most other natural grasses found on pastures, but which are unpalatable in their natural state because of their essential oil and fibrous nature spoilt the silage. The smell persisted and the silage was refused by the cattle.

Hay.—Over the same years also, hay was prepared from the hilly areas the species being chiefly *Heteropogon contortus*, ~~*Selina*~~ *nervosum* and *Themeda triandra*. The period during which quality hay was produced was found to be limited to 6 weeks. 80 lb. bales were found to be readily saleable at 12 annas. Analysis showed that grasses cut from the fairly steep hill slopes were deficient in minerals, as compared to those of the plains areas. Palatability was high compared to paddy, *ragi* (*Eleusine coracana*) and *cholam* (*Sorghum vulgare*) straws.

In dealing with this subject I have found that the local owner prefers to wait until the grasses have ripened fully and dried on their stalks. He can then cut bulk cheaply. He seems to study hay only from a bulk point of view irrespective of the feeding value. In reply to a question as to why he was cutting dry bulk with no feeding value instead of buying bales of good hay, the permit holders' reply was that his bulls ate too much of the good hay and ate it too quickly, and any way he fed good concentrates and all he wanted was bulk to help its digestion. His bulls I may say were in first class condition.

5. Artificial introduction of grasses

No difficulty was found in introducing *Cenchrus ciliaris* both in combination with field crops as already described under 3 above, or by sowing broadcast after ploughing. The last method is expensive, and is not justifiable. Small scale experiments were also undertaken and the following species tried on the advice of the agricultural department.

1. *Sehima nervosum*. 2. *Iseilema laxum*. 3. *Iseilema anthephoroides*. 4. *Andropogon pumilis*. 5. *Andropogon foveodatus*. 6. *Chionachne koenigii*. 7. *Cenchrus setigerus*. Of these, numbers 2, 3 and 6 failed completely, Nos. 1, 4 and 5 were fairly successful, and 7 was excellent.

As a measure of erosion control in gullies a small scale trial of giant star grass (*Cynodon plectostachyum*) has proved very successful on silt held up by small dry stone bunds.

In general my experience is that a mere ploughing—preferably along the contour—in degraded pasture creates a good germinating bed for the seed of the natural grasses that would otherwise lie on the hard surface and fail to germinate. If done with the premonsoon showers, the result is an immediate increase of herbage up to 3 to 4 times the original. This, given closure during the subsequent monsoon, is much better developed than the original and can be put under deferred grazing the first year, to be followed by rotational grazing in subsequent years. Located where grazing is in demand, a revenue of Re. 1 per acre per annum on such improved pastures is by no means unusual, and this over a period of years.

I must admit that in the matter of introduction of legumes—of supreme importance to my mind—little has been found possible. Both *Alysicarpus rugosus* and *Rhynchosia minima* were successful, but neither proved particularly palatable to cattle and both are

annuals. We still look for a legume similar in nature to the wild white clover (*Trifolium repens*) of temperate countries.

6. Improvement of water supplies in grazing grounds

In the North Coimbatore division there are many old tanks, relics of a previous civilization the history of which has been lost. Some are silted up and some have breached. It was found possible however at a very small cost to repair and improve such. Bunds were cleared and repaired, surpluses constructed, and in some cases systems of trenches were made to tap the run off from outside the natural catchments. In general the principle was to aim at a supply sufficient for 300 head of cattle. In some cases springs were opened up and led into small cisterns. By this means the pressure of grazing was distributed much more evenly, especially in penning areas. The number of penning sites was increased and it was found possible to limit the number of cattle allowed to any individual pen.

7. Erosion control

I mention this purely in so far as its relation to pastures is concerned. In the special blocks described in 2(*b*) above it was found that interrupted bunds of loose stones constructed along the contours and arranged roughly in echelon resulted in an appreciable increase of herbage on the hill sides. Such bunds about 2 ft. base and 1 ft. high result in increased percolation which is reflected in the grass crop. They also trap seed that would normally be washed away. A certain amount of cheap gully plugging with rough stone was also carried out. The fact that the local *ryot* sent his labourers to help in such work at half pay is sufficient proof that he appreciated such measures.

On the whole, experience is that the most effective way of limiting erosion is by regulated grazing, ensuring the maintenance of a good soil cover, and that it is unnecessary to concentrate too much on expensive artificial works. It is considered that expensive measures such as contour trenching can never justify themselves financially despite the spectacular results, and that control should be built up gradually rather than attempted in one operation. My remarks refer to our forest pastures and not to agricultural lands.

8. Research

Under the research scheme, despite war conditions, it was found possible to undertake a fair amount of work. This was concentrated on a type of pasture typical of many thousands of acres in this province. The soil was red ferrugineous loam derived from felspathic and hornblende gneiss. Rainfall over 10 years averaged 28 inches distributed between the 6 monsoon months and six non-monsoon months 18.5 and 9.5 inches respectively. Total number of rainy days 46, and 24 respectively. General conditions, reliable thunderstorms April-May and September-October, a very unreliable-south west, but a reliable north-east monsoon.

The botanical compositions of the pastures were:

1. Overgrazed areas.

Average on 3 ft. x 3 ft. quadrat by actual count—

Amphilophis pertusa	122.2
Chrysopogon montanus	28.0
Eragrostis bifaria	49.8
Other species, chiefly *Aristida depressa* and *Oropetium thomaeum*	18.7
Weeds	18.0
Total	236.7

2. Pastures Improved naturally (by closure) average per 3 ft. x 3 ft. quadrat.

Amphilophis pertusa	47.3
Heterepogon contortus	87.0
Chrsopogon montanus	17.3
Other species, chiefly	
Aristida depressa	28.4
Eragrostis bifaria	93.1
Weeds	26.3
Total	299.4

These analyses show clearly the improvement in stocking and the botanical changes that result from an effective closure such as that given to fuel coupes which have been clearfelled.

Personal observation has also shown that in such pastures, the conditions can be determined by a survey of the species present. The natural succession of grasses starts with *Aristida hystrix* and *Funiculata*—Pioneers, followed by *Chrysopogon montana*, *Aristida depressa*, *Eragrostis bifaria*, *Amphilophis pertusa*, and seems to reach a climax with *Heteropogon contortus*.

The indications given by the various experiments are briefly stated below.

Overgrazed pastures. Carrying capacity when grazed continuously.

3 intensities were under test for 1 cow unit per 3, 4, and 5 acres. The treatment was given for 3 complete years at the end of which time the heavier intensity had resulted in slight but very definite deterioration with sheet erosion in small patches. *Amphilophis pertusa* was disappearing leaving a pasture largely consisting of *Chrysopogon montanus*, *Eragrostis bifaria* and *Aristida depressa*. Shrubs such as *Acalypha fruticosa* were heavily browsed, adequate indication of a shortage of grass. The lighter intensity of 1 cow per 5 acres resulted in a very definite improvement in the pasture, despite continuous grazing. *Heteropogon contortus* began to make its appearance in the better areas, while *Amphilophis pertusa* invaded appreciable areas which had hitherto carried only *Chrysopogon montanus*. At the close of the rains, both 4 acre and 5 acre intensities came up to full flower, a marked difference to the 3 acre intensity, both in the height of the crop and in composition.

The conclusion reached was that to prevent further deterioration in overgrazing pastures the intensity of grazing should not exceed 4 acres per cow unit. Unconnected with the experiment, but of interest while dealing with overgrazed pastures the result of an attempt at improvement by controlled grazing is, worth noting. At the special request of a group of cattle breeders an area of some 250 acres of degraded pasture was set apart in 1941 and grazed rotationally with an intensity of 1 cow unit per 5 acres, a special fee of 0-4-0, per head being paid by them. In 1942 the intensity was increased to 4 acres per unit. In 1944 it was grazed on the same intensity but with a special fee of 0-8-0 per unit. By 1945 the intensity was increased to 3 acres per cow unit on an 0-8-0 fee. War inflation has not touched the grazing fee in Madras, and I think that hard facts such as this require no statistical analysis.

Pastures improved naturally (by closure). Carrying capacity when grazed rotationally.

3 intensities, 1 cow unit to 1, 2 and 3 acres were under test, each paddock being divided into 5 sub-paddocks for the application of the rotating principle. Grazing was carried on throughout the year. At the end of 2 years the heavy intensity was obviously deteriorating and was cut out. Both 2 and 3 acre intensities suffered little over 3 years treatment, and in both the stocking of *Heteropogon contortus* remained steady. After the rains they came up to full flower and in doing so invariably attracted elephants during November-January. The indication is that in pastures of this type an intensity of $2\frac{1}{2}$ acres is safe, provided grazing is rotational. This conclusion is again backed by 4 years experience in our special blocks where intensities of 1 unit per $2\frac{1}{2}$ or 3 acres has been fully successful, and there has been no single case of degrade.

Variation of period of utilization.—This series was a combination of early opening, early closing and late closing. Early opening was prescribed as soon as the pastures were ready for grazing after the dry months of February-March. Late opening two months later. Early closing was fixed at January 15 and late closing at March 15. Once opened the pastures were kept grazed back throughout the season, but overgrazing was carefully guarded against.

The conclusion reached was that provided there was no overgrazing, the earlier the opening, and the longer the season could continue the better. Nothing was to be gained by denying the early bite to the cattle, while early closure left too much stubble resulting in slow response to rain. Late closing had the advantages of making the dry stubble available for the cattle, together with quick response to rain.

Manurials.—Four treatments were tried against a control. Lime, groundnut poonac meal, steamed bone meal, and farmyard manure. The treatments were applied in August-September at a time when rain was expected. It was found that the pasture was very slow to take up lime, groundnut, poonac meal and bone meal and no appreciable result was noticeable either as regards response to rain, or production of herbage. A dressing of 4 cart loads of F.Y.M. per acre however resulted in marked improvement. Response to rain was quick and the pasture stood up to grazing well. During 1943-44 this paddock carried an intensity of 1 unit per 1.3 acres as against the next best of 1 unit to 1.6 acres.

Live Fences.—Species tried were *Euphorbia antiquorum*, *Euphorbia tortilis*, *Agave americana*, *Dendrocalamus strictus*, *Commiphora berryi*, *Acacia ferruginea*, *Acacia arabica*, *Acacia planifrons*, *Prosopis juliflora*, *Cassia siamea*, and *Pithecolobium dulce*.

The most successful for quick results was *Commiphora berryi* planted as cuttings 4 ft. $\times$ 1 to $1\frac{1}{2}$ in. diameter in crowbar holes 6 to 9 in. deep. Aloe failed after a very promising start due to porcupine. *Euphorbia tortilis* cuttings were fairly successful but growth was slow. *Acacia arabica* failed, but both *A. ferruginea* and *A. planiframs* were successfully raised in lines with repeated soil workings. Pure lines of *Prosopis* and *Pithecolobium* were found very liable to insect attack and inclined to be patchy. *Cassia siamea* though not successful in this experiment, has been widely grown in lines elsewhere. It is proof against cattle as the leaves are repellant and it stands cutting well.

9. Progress in the regulation of grazing in divisions other than North Coimbatore

Serious attempts at improvement by controlled grazing in the province start from 1939-40. I have no information of the details of methods employed. It may however be taken that limitation of numbers admitted to the various areas has been enforced without creating serious opposition from the public.

In 1939-40 a total of 14,318 acres of worked coupes in 2 divisions and 40,187 acres of other areas were placed under control. By 1945-46 the areas under control totalled 29,645 acres of worked coupes in 3 divisions and 26,500 acres of other areas in 1 division.

From figures given to me I notice that attempts have been made to introduce control in 10 divisions, but that efforts have come to nothing in 5 divisions.

A fair claim is that a start has been made in years of extreme difficulty when the energies of the staff have been very often concentrated on priorities such as fuel supplies. This is encouraging, and with more time at the disposal of district forest officers an improvement may be looked for.

I make no apology for this long note, dreary though it may be, and have deliberately written *in extenso* because of my experience at the husbandry wing of the board of agriculture meeting in February, 1945 when I found that so little was known of the work being done by the forest department. In this matter I draw attention to the recommendation (4) under subject 8 of the proceedings of that meeting which reads :

> *Available information on range and grassland management in India should be collected and made available. Research should be undertaken with a view to obtain further information.*

I have before me the resolutions of our silvicultural conferences of 1939 and 1945.

In Madras I feel that we need no longer agree to such resignation to the inevitable as is the spirit for example of resolution 1 of 1939, and that elsewhere also such simple investigations as have been carried out all show results of which we can be proud. I plead that a stage has been reached when we can say with confidence that we have a just case in the interests of both cattle and forests to claim a change in policy where it has not yet been granted, that we are not talking on theory, but that we have our demonstration areas which can be seen for themselves. Our pastures can be improved on certain conditions and the position now is that we can tell our respective governments what those conditions are. There is however, one stumbling block operating to the disadvantage of all, and that is the financial side of this subject. So long as governments persist in placing a nominal valuation on forest grazing instead of a fair charge, we shall be faced with the herds of scrub animals that are typical of all areas where cheap or free grazing is in vogue. Apart from being largely an inequitable subsidy to those living near our forests, it is the most potent factor against progress both in animal husbandry and pasture improvement.

WERE FORESTER GRAZING PLACED ON AN ECONOMIC BASIS MANY OF OUR DIFFICULTIES WOULD GRADUALLY DISAPPEAR. THIS FACT SHOULD, I THINK, BE RECOGNISED AND A RESOLUTION ON IT PASSED AND PLACED ON RECORD.

On the matter of research there is a strong feeling in this province that we have sufficient technical information to proceed to the first essential on a large scale, *viz* :—the improvement of our degraded pastures, and the management of such pastures once improved. The putting into effect of this knowledge is a matter for administration to deal with. Having improved out pastures, research can

then function to help us in investigation of the finer details. Being deliberately provocative at the moment I would ask our scientists to give a plain reply to two straight questions.

(1) When were the first researches initiated ?

(2) Has any significant result been obtained in any scientific grazing research that can stand statistical analysis ?

If after so many years of effort we have no appreciable results of research—I refer to research scientifically conducted—I think the time has come for straight talking, and would quote from an article by Sir R. G. Stapledon on "Ley Farming and Long Term Agricultural Policy" in 1938. I hope the author needs no introduction to the conference.

I again quote *in extenso.*

> In passing I might say that in my view no problems so much as those of grassland demand prolonged and large-scale agronomical investigation. I would wish to distinguish between, on the one hand, agronomical research, and on the other, scientific research as normally understood and conducted. The major aim of *agronomical research,* which is *essentially field research,* is to study all the factors which are operative at once and together, and in their natural interplay, for 'nature is a theatre for the inter-relations of activities'. Such a procedure, it may be said, is impossible, or at least unscientific. It is certainly not impossible, and if it is unscientific it will yet remain agronomical, and *many of the problems of agriculture are more likely to be solved, shall I say, by agronomical investigation than by scientific research* whil enearly all the results of scientific research have to pass through the sieve of an immense amount of agronomical investigation before they can be made useful, and in some cases perhaps before they can be other than positively dangerous to the practitioner. *The technique of agronomical research entails a great deal more* than blindly following all the *elaborate rules and regulations* laid down *by the statisticians;* indeed, *such rules and regulations* are of *no fundamental significance* in the proper planning of an elaborate series of field experiments.
>
> They are sometimes, but by no means always, useful in the actual placing of plots on the ground, and they are sometimes essential, but are *by no means always necessary in the examination of quantitative data. One effect of the modern glorification of statistical methods has undoubtedly been a tendency to obscure the wood for the trees* to concentrate on the part, often an isolated part (yield for example), instead of the whole; and, worse still, to fill the agronomist with a medley of complexes and inhibitions which have reacted adversely on the development of a technique adequate to solve a large number of the problems that can be solved only by highly complicated field experiments. Many agronomists are almost too frightened to set up the sort of experiments their experiences teach should be set up, *because they are timorous lest the data could be made amenable to statistical analyses. Agriculture would have been the gainer if the agronomist had never been taught to be timorous,* and if he had plodded away undeterred and undismayed at the details of his own technique, when by now perhaps he would have been able to justify his claim that what is primarily wanted to-day is enormously increased facilities for the conduct of field experiments in contra-distinction to field trials and demonstrations.

My feeling is that we are at present inclined to neglect the practical side of our grazing problems, and cover this neglect by awaiting results of a long-term programme of research. Our immediate problem is with our various governments who are responsible for policy, and our remedy lies in convincing them of the truth of our arguments; given their support, large-scale results could be attained in a short time based on the experience already available.

A NOTE ON FOREST POLICY

A NOTE ON FOREST POLICY

WITH SPECIAL REFERENCE TO WEST BERAR DIVISION (1894—1944)

BY RAO SAHIB V. P. MATHUR

(*Divisional Forest Officer, West Berar Division, C.P.*).

Introductory

The Forest Policy as laid down in circular No. 22-F, dated 19th October, 1894, was not the result of any infringement of the rights of individuals or classes, but was literally the repetition of what had already been laid down and accepted as the basis of forest administration in India. The reason which prompted the government to issue a circular, for which there was no obvious necessity, is given in para. 1 and in para. 2 are given the general principles.

The principles which govern the policy are :—

(*a*) The areas necessary on climatic and physical grounds must be preserved.

(*b*) The minimum amount of forest necessary to supply the present and prospective requirements of the neighbourhood must be maintained,

Subject to (*a*) and (*b*),

(*c*) Claims of cultivators are more important than forest.

(*d*) Realisation of revenue comes after the wants of the local village consumer have been satisfied free or at commercial rates.

A broad classification of the forests for the purpose of the application of the general principles enunciated in the policy are given in para. 3 of the resolution and there it has been emphasised that a forest may fall in one or more of the classes. Broadly, the forests were classified as:

(*a*) Those necessary on climatic or physical grounds, *i.e.*, protection forests. Here the principal object was protection. These forests had to be preserved under any circumstances. The needs of the population, either for land or for produce, had no demand on these.

(*b*) Timber forests. The principal object here was revenue. These forests by virtue of their being generally (not always) situated in essentially forest tracts were to be worked on commercial lines and were to be a source of revenue to the state. But even here, certain points were to be kept in view, *viz* :—

(*i*) Every reasonable facility was to be offered for the full and easy satisfaction of the needs, either free or at low cost, of the communities dwelling on the margin of the forest.

(*ii*) Even where conditions were suited to the growth of larger timber for merchants, it was to be carefully considered whether or not it would be in the interest both of the people and the revenue to work them with the object of supplying the requirements of the general and, in particular, of the agricultural population.

(*iii*) Subject to certain conditions, the claims of the cultivators were stronger than the claims of forest preservation.

(*c*) Minor forests. The principal object was the supply of local needs.

(*d*) Pasture forests. The principal object again was local need.

Although the policy as laid down did not wish the forests in the country to be divided into various classes, in fact, it was clearly recognised that no such classification could actually be possible. In Berar attempts were made to classify the forests as early as 1870.

By a Notification of 1888, the reserved forests were divided into two classes. Class A was permanent reserve and class B had two subdivisions. In one subdivision were listed areas selected from time to time as available for cultivation, and in the other subdivision were included all the other areas. In 1892, the state forests were reclassified into :—

Class A—Which included forests meant for the production of timber.

Class B—Which included areas for production of high grass.

Class C—Which included pasture lands and had two divisions.

Class D—Which was fluid.

In 1902, the Berar Forest Law came into force and in accordance with its provisions, the forests were again classified as under :—

Class A—Were for the production of timber and fuel and had two divisions.

A–II. Areas which were mainly forest tract such as Melghat and Ambabarwa.

A–I. Areas other than those included in A–II.

Class B—Were areas of high grass.

Class C—Were pastures and had 3 divisions.

Class D—Were village forests.

In 1913 came the classification now in force and the Notification divided the forests into two classes :—

Class A—Included old Class A division I, Class A division II, and Class B.

Class C—Included the rest.

It would appear from the changes made in the classification from time to time that in 1907 (as a result of the Berar Forest Law) an attempt was made to classify the forests in accordance with the principles laid down in the policy, but in 1913, (after the application of the Indian Forest Act to Berar in 1911) that classification again changed. It was a recognition of the fact that rigid and detailed classification according to the uses to which the various types of forests were to be put was not possible.

In 1933 a classification for the control of grazing was made within the existing classification. It was however unfortunate that

this, instead of being made on the function which the different types of forest were to perform, was made according to the growth found at different places. This frustrated several important objects of the resolution.

Past Policy

In order to study how the policy has been applied in the past and how different types of forests have been managed, each type in broad classification mentioned in para. 3 of the Government of India resolution, is discussed below.

(*A*) *Protection forests.*

None of our forests were reserved because they were considered necessary on climatic or physical grounds. They were reserved because they were waste lands. In this category, in this division, will be included most of the C class areas especially in Buldana district and many of the A class areas, including some of the *babul* (*Acacia arabica*) *bans*.

C class areas have unlimited grazing and also satisfy certain privileges with regard to the removal of grass, thorns and fuel, etc. Rotational closure of some of the C classes in Buldana is of recent origin and is only with a view to improve the grazing. In A class, certain areas are closed to grazing for short periods after working, and grazing is limited. Green timber and fuel are only removed from areas under working. That these forests were necessary on climatic and physical grounds had not been recognised till very recently and even when it was recognised, nothing was done to safeguard them against destruction beyond, probably, a direction in the working plan that such areas when they occur in a coupe, should be left out of working. These instructions only apply to A class workable areas which are usually the least susceptible to damage by erosion.

C class forest, which usually needs protection the most, is probably being treated worse than it was when it first came to be reserved. Heavy grazing by browsers, which is one of the chief causes of erosion, has not been restricted. These C classes had been reserved as pastures originally, and are being treated as such even now when it is recognised that their reservation should have been originally not for pasture but for protection. Had these forests been recognised as protection forests from the very beginning and had the principles laid down in the policy been rigidly applied, the serious problem of erosion with which we are now faced would not have been so acute.

(*B*) *Timber forests.*

A guide to this class is provided by the Berar Act and the classification of 1907. In this class should actually be included only Ambabarwa reserve (which the 1907 classification included) and possibly Narnala reserve. The rest of the timber and fuel forests of A class of this division should really form part of the next class of forest, as they are intermingled with permanent villages and cultivation. As, however, there are no customary rights or privileges which might militate against their management as revenue paying properties, they actually get included here.

The immediate object of management in this class is the satisfaction of the demand of the local population, but the disposal of the produce is on commercial lines. The forests are considered as legitimate source of revenue. According to the policy every reasonable facility was to be afforded to the communities dwelling on the margins of this forest for the full and easy satisfaction of their need for timber, fuel, grass and grazing "if not free, then at low and not competitive rates." It was to be distinctly understood that considerations of forest income were to be subordinated to those of satisfaction. As long as the system of commutation of *Nistar* and *Paidawar* was in force, this policy was to some extent given effect to, but since that system got abolished, this policy, so far as all timber and most of the fuel requirement of the public is concerned, is not being adhered to.

That the policy of the Central Provinces government, as far as timber and fuel are concerned, has been to manage all A class forests in this division on commercial lines, is clear from the following extracts from the orders of the local government on special revenue officer's report on the question of supply of timber and fuel to agriculturists, dated 7th December, 1912 *vis-a-vis* the prescriptions of the Akola working plan.

"Para 12. (The Chief Commissioner) thinks that having regard to local conditions in Berar and looking to the fact that the Bhandara coupe-in-advance system entails considerable incovenience, it would be very inadvisable to take any measures that would tend to interfere with the disposal of the outturn from the forests on the commercial lines that have been in force for many years past".

In regard to other requirements *viz.*, grass, grazing, leaves, etc., although they are not allowed free, the rates charged are low and not competitive. Edible fruits are allowed free in Buldana district but are charged for in Akola.

In paras. 6 and 7 of the resolution it was emphasised that, subject to certain conditions, the claims of cultivators are stronger than the claims of forest preservation. This aspect of the policy has been given more attention than any other, and usually without considering the proviso. The conditions had for their object the greatest good of the community. Honeycombing of the forest was not to be allowed, the cultivation was to be permanent, the cultivation was not to be nominal, and lastly, but most important, the cultivation was not to be allowed so to extend as to encroach upon the minimum area of the forest which is needed for the general forest needs, present and prospective. The first and second conditions were generally given consideration, the third only sometimes and the last was almost always lost sight of. Had the third and fourth conditions been given effect to sufficiently, disforestation in Akola and Buldana, which have only 7 and 11 per cent forest area, would not have been allowed to occur.

(*C*) *Minor forests.*

Except in so much as the production and supply of timber is concerned, this class includes all the forests of the division. These forests were to be so managed as first, to preserve the wood and grass from destruction and second, to supply the produce of the forest to the greatest advantage and convenience of the public. To these two objects all considerations of revenue were ordinarily to be subordinated. It was however made clear that it was not the intention of the government to forego all revenue. For this certain principles were laid down for guidance.

(*i*) Where the areas afforded only grazing or only supplied fuel to the villages which lie around or within them, the necessities of the inhabitants were to be treated as paramount and were to be satisfied at the most moderate rate and with as little direct interference as possible. To achieve this many of the old reserves in the vicinity of the villages have been disforested and turned into E class lands. To supplement the supply further, C class reserves have been thrown open for free supply of the *bona fide* requirements of fuel, thorns, etc., of the villages in the close vicinity of the forest. Fuel, *thorns*, *leaves and various* other produce is allowed to be removed at scheduled rates from A class reserves. A certain number of cattle are allowed free grazing in the C class reserve and a further number is allowed at concessional rates in A class reserve. The policy of as little direct interference as possible is given effect to further by offering grazing to village *panchas* in *babul bans* for the term of revenue settlement or for 5 years. That this has not been made more universal is due to the apathy of the villagers themselves.

(*ii*) Where the village tract had ample grazing ground, and crown lands only supplemented these pastures, the government "may justly reap a fair income." Even here, the convenience of the graziers was to be considered and the inhabitants of the locality were to have a preferential claim. For the satisfaction of this principle, after a certain number of cattle is allowed to graze free and another number allowed to graze at a nominal rate, a very low rate is charged for the privilege of further grazing in A class. For the convenience of grazing, villages in the vicinity of the forest are attached to certain fixed units where they can of certainty find grazing.

(*iii*) The rates for grazing were to be materially lower than the rates to be obtained in the open market. The rate paid by the agriculturists are only nominal and even commercial rates are at a least 1/4th of the rates charged by contractors and private owners.

For about 16 lacs of cattle grazed in the government forests in the whole province about 10 lacs of rupees are obtained as fees.

(*iv*) Fixation of grazing demand upon a village for a year or a term of years was suggested. This was with a view to minimise extortion by petty officials. This question was considered and orders issued by the government in 1931 for some of the *babul bans*, but the system has more or less proved a failure. The villagers did not wish to commit themselves for longer terms such as the term of revenue settlement and only very few agreed to a term of 5 years.

(*v*) Further, where grazing fees were levied *per capita*, free passes for a certain number

were to be given not only for plough bullocks but also for a number of milch cattle. Plough bullocks are allowed free in C classes but not milch cattle.

(*vi*) Fuel and fodder preserves were suggested for formation and it was left to the local administration to decide whether a particular area can be made to support a greater number of cattle by preserving grass and cutting fodder. It was to be remembered that the action taken was for the advantage of the neighbourhood and that a larger revenue by sale of produce to the highest bidders was not always in accordance with the policy of the government. Circumstances were to decide. If the local supply was greater than the demand, the produce could legitimately be disposed of.

As has been stated before, if timber is excluded, the policy laid down for this class of forest has been rigidly given effect to. Fuel is allowed free or at concessional rates (scheduled) and all worked coupes closed to grazing and many A class forests, classed as *ramnas*, form the fodder reserves. The former very rigidly, and the latter mostly, are not auctioned to contractors. The fodder in them is sold at fixed rates which are only nominal. In case it is considered that villagers will not be inconvenienced by such action or where the watch and ward are impossible the areas are auctioned but only after due consultation with the deputy commissioners. Even so, preference is given to the villagers for their purchase.

(*D*) *Pasture and grazing grounds.*

In this class may be included all the C class forests and some A class, such as scattered *babul bans*. It was still an open question whether such lands should remain under the administration of the forest department and the directions following applied to these lands —including crown waste lands not declared to be forest. Here the interests of the local public reached their maximum, and those of the general public were considered to be of the slightest nature. It was thought that where the tenure of land is *ryotwari*, the difficulties were the most aggravated.

Actually, in this class should come only the scattered *babul bans*, even though the C class reserves are the actual pasture lands. The C class forests are usually not intermingled with cultivation while *babul bans* are. Whether C class or A class *babul bans*, most of the areas under the forest department which proved troublesome to the villagers have long ceased to exist. In this division, a large-scale enquiry was made and a number of such *babul bans* were disforested. The disforestation only stopped when it was found that the villagers themselves were against such disforestation. Most of the disforested areas were retained as village grazing land (E class).

In para. 14 of the policy it was suggested that it should be distinctly understood that the grazing should not be looked upon primarily as a source of income. At the same time it was pointed out that this did not mean that revenue from scattered forest should be relinquished. It was directed that if the management is placed in the hands of the resident cultivators, the objections to direct management are redueed to a minimum and that the unoccupied lands should be leased or managed through the agency of the village community, at a moderate estimate of their value to them.

This question was considered more than once by the government and it was decided that the management of such areas through the village community was fraught with great danger. Proposals for managing some of the forests in a parallel way were drawn up and submitted in 1932 but they were dropped. Before such action as directed above can be given effect to, it is necessary that the village community is sufficiently trained to the knowledge that the area which they manage is for the good of all and must be preserved permanently. Another snag is that the small survey numbers, intermingled with actual cultivation, are usually too small to supply all the grazing of a whole village, and as such it is not likely to commend itself to the attention of a whole community.

Achievements Summarised

It will be seen from the foregoing paragraphs that the policy has been rigidly given effect to in certain respects, but not in others. In the case of supply of all timber and most fuel the policy, which could have been followed without the slightest harm or any adverse effect on the forests, was not given effect to because revenue, which was not to be the aim, guided the policy of the government

All the forests are actually worked on a commercial basis. On the other hand, in the matter of grass and grazing, in which the policy itself was so liberal as to be detrimental to the forests, it was more or less rigidly given effect to. The government in their anxiety to provide cheap and ample grazing to the villagers even transgressed the principle of not working the protection forest. In fact, by the 1932 classification of forests, the unworked forests irrespective of whether they were protection forests or others, were thrown open to unlimited, unrestricted and continuous grazing. Working them for timber or fuel would not have been detrimental, but heavy grazing has started the problem of erosion.

The resolution had rightly laid down that the forests shall be managed in the interest of the population and that revenue was not to be the aim. This principle more than any other, has been completely disregarded. Any new venture or project has no earthly chance of being approved unless it is shown to be profitable. To spend money without any hope of return is simply unthinkable. No money is ever spent on forests which do not give a large return, much less on those which must continue to exist in the larger interest of the country. In this division where the forest blocks are far apart, a forest guard has sometimes to do watch and ward over as many as 180 square miles. Considering that all those blocks are surrounded by cultivation where thefts are common, the forest guards beats should have been smaller and staff bigger so that the forests continued to exist. As it is, thefts are in some cases so heavy that if this state continued long enough the forests may disappear.

Certain other principles laid down in the policy could not be given effect to either because the detailed instructions in the policy were not sufficiently clear, were ambiguous, or were open to misinterpretation and, in several cases, were self-contradictory. Certain very important principles were not given sufficient prominence and were totally lost sight of.

Future Policy

The broad principles of the policy were very sound and even after a lapse of 50 years remain so. The details, however, in several instances need clarification and correct direction

To begin with, although it was clearly recognised that the existence of forests was of vital importance, not only to the village community but also to the whole nation, those principles which were vital for the continuity of the forests themselves were so lightly and casually dealt with in the resolution that the forests are generally, and amongst the forest officers with certain amount of pride, taken to be only the "handmaid of agriculture". If the forests are not to be lost for ever—and with them the agriculture of the province—it must be clearly and definitely laid down that the forests are something more than the handmaid of agriculture and should be given a place of equal importance in the national economy.

Although it was recognised that a certain minimum of forest area was essential for the well being of a people, this minimum was not prescribed and the fact that the exising forest may not be that bare minimum, and further reservation or creation to reach that figure may be necessary, was lost sight of. It is absolutely essential that in any future policy a safe figure of well distributed, easily accessible forest is prescribed as the minimum and that goal reached by legislation if necessary.

The resolution laid down principles for the management of the reserved forests only and made no mention of those forests or waste lands which, not being reserved, were either owned by the government or private individuals and should have been managed in the interest of the country. Thus, under protection forests, management of only those areas which were reserved under the forest act was indicated even though all such forests whether private, state, or reserved were equally important for the good of the country. It is necessary that all land, whether government property or not, which must be protected in the larger interests of the country, is brought under control.

Although in the very beginning of the resolution it was made clear that the object of administration of state forests was public benefit and that in some cases the public to be benefited were the whole body of the tax payers and also that the right should be enjoyed in such a way that the enjoyment did not lead to the extinction of the forests, this important principle was nullified by laying too great an emphasis on the past rights of users or privileges enjoyed by one

class of public *viz.*,—the local village population. This principle laid a premium on past practice and gave an undue weightage to the demand of such consumers to the detriment of the larger and more important interest of the general public. By allowing free or at a nominal cost the unrestricted supply of timber, fuel, grass and grazing, irrespective of their *bona fide* requirement, the very first principle that the forests were to be managed for public benefit was seriously jeopardized. In fact there was nothing to safeguard against the extinction of the very forest from which the privilege was to be enjoyed. It is very essential that individual demands are restricted if they clash with the larger interest of the country, and in any future policy this principle must be clearly laid down.

Finally, it must be reiterated that revenue production is not the chief aim and that the government must fully realise that the areas like the protection forests and the minor forests will have to be conserved even without their yielding any revenue. Unless this important principle is not only recognised but emphasised, forests such as in Berar will in the long run disappear.

THE WATER COMPLEX OF THE MELERA VALLEY *

BY HANS BURGER

Translation of summary by

A. L. GRIFFITH, D.Sc.

(*Central Silviculturist, Forest Research Institute, Dehra Dun.*)

FOREWORD.—In our issue for August 1945, pp. 285-86, we published a review of a translation in English by Dr. Griffith, of the famous Emmenthal erosion experiment which had been carried out by the Swiss Forest Research Institute at Zurich for some 36 years.

Prof. Burger has recently published further work on a similar subject in a Swiss valley in which the vegetation had been devastated but which has been under afforestation and protection for 10 years.

This work and the Emmenthal work referred to above, give very interesting and important data on rainfall intensity, runoff, and erosion and particularly on the great effect the moisture condition of the surface soil at the time the rain starts, has on the resulting runoff.

The following is a translation of the summary of this new piece of work. It will probably interest many of our readers who had the privilege of meeting Prof. Burger during their training but who may not now have access to his work.—*Ed*.

In the course of completion of the water complex research of the Sperbelgraben and Rappengraben of the Emmenthal † and after a preliminary examination, the necessary apparatus was put up in 1934 to examine the water complex of the Melera valley which is a side valley of the Morrobia. This was carried out with the kind help of the canton of Tessin and Fonds for the E.P.F. jubilee of 1930.

The catchment area

The Melera valley is 105 ha. in area and varies in elevation from 962 m. to 1773 m. The average slope is about 54 per cent. The geological sub-soil is of several kinds of gneiss which are covered more or less thickly by material which comes from moraines and from the higher levels of the basin.

In general the soil is more light and permeable, and the surface flow less than is the case with " nagelfluh ", (a conglomerate of pebbles and limestone. *Translator*) " flysch ", (a mixture of the sediment from chalk and from eocene rocks which gives a very good soil—*Translator*), mica schists etc. Nevertheless the runoff here is also higher in the pastures than in the meadows not grazed by livestock and still more so than in the forest. The relatively drier soils generally absorb the precipitation better than do the

*BURGER, H. 1945. *Proceedings of the Swiss Forest Research Institute*, Zurich, Vol. 24, Part I.

†For a description of the Emmenthal erosion experiments please see the ***Indian Forester*** **for August 1945, and** ***Indian Forest Records*** **(*Silviculture*) Vol. 6, No. 1.**

relatively wetter soils, but the dry soils with a dusty consistency, after the start of rain, allow much water to run off on the surface until the resistance that they offer to wetting is overcome.

In 1914 in the Melera valley one only met the remnants of beech coppice regrown in a neglected pasture land with scattered bushes. The first reforestation and erosion defence works were started in 1915 and the work was programmed to be completed by 1934 but by then at the top of the basin there were still some 15 ha. of bare pasture but that also was to be afforested.

The local climate

The mean annual temperature of the decade (1934/35 to 1943/44) shows, near Alpe Urno 5.5°C. The absolute minimum was –20°.3C and the absolute maximum 28°.8 C, 49° thus being the temperature range. The coldest year was 1940/41 with a mean annual temperature of 5°.3 C and the year 1942/43 was the hottest with a mean annual temperature of 6°.3 C. The minimum daily temperature usually occurs about 6 a.m., a little earlier than this in the summer and a little later in the winter. The daily maximum temperature is usually registered between mid-day and 2 p.m. The temperature at the same altitude is higher in the Melera valley than in the Emmenthal, particularly in winter because there is more insolation in the Tessin.

The relative humidity during the decade was about 77 per cent and varied little from year to year. The air is noticeably drier in the Melera valley than in the Emmenthal where it is generally humid from September to February and relatively dry from March to August. At Melera it is from November to April that it is particularly dry while the months of May to October are characterised by a more humid atmosphere.

By taking the mean of 6 rain gauges the annual precipitation was found to be 2105 mm. The lowest recorded was 1386 mm. in 1942/43 and the highest 2800 mm. in 1935/36. Thirty-five per cent of the annual mean falls during the winter and 65 per cent in the summer. The annual variations in the Melera valley are much greater during the 6 winter months when they vary from 242 to 1436 mm. than in the 6 summer months with the much smaller variation of from 1029 to 1542 mm. It is thus the winter precipitations which generally determine the dryness or humidity of the year. From December to February only 11 per cent of the precipitation falls while on the other hand 32 per cent falls from September to November. It is probable that insufficient elimination of the effect of the wind reduced the total measured precipitation by 100 to 200 mm.

Heavy falls of rain of short duration often occur in the Melera valley and falls of 50 to 60 mm. in 30 mins., of more than 100 mm. in 12 hours and of up to 200 mm. in 2 days are common.

Snow starts from the beginning of November at the upper limits of the catchment. The top half is covered with snow from the end of November, the lower half is not so covered until the second half of January. From the beginning of February the snow limit retires upwards, at first slowly up to the first days of March and then more rapidly till at the beginning of May the valley is usually clear.

The water complex

The relation between the precipitation, runoff and evaporation for the decade 1934/35 to 1943/44 was as follows :—

Season	Precipitation mm.	Runoff mm.=per cent.	Vapourisation mm.=per cent.
Winter (Nov. to April)	736	585 = 79%	151 = 21%
Summer (May to October)	1369	878 = 64%	491 = 36%
Whole year	2105	1463 = 70%	642 = 30%

Thus in the Melera valley, of the total precipitation 70 per cent went as runoff and 30 per cent as vapourisation (*i.e.* evaporation and transpiration). The percentage of runoff was much higher in winter than in summer while that of the vapourisation was similarly smaller.

Forty per cent of the annual runoff took place in winter and 60 per cent in summer. The vapourisation was as follows :—23 per cent in the cold season and 77 per cent in the hot season. It is in May that the Melera valley shows the highest runoff, because the region of the Brenno and the Moesa, which is above it, has its monthly maximum only in June due to the melting of snow and glaciers.

Vapourisation is smaller than in the Emmenthal because the water penetrates much more rapidly into the lower layers of the soil. If we assume as we have already suggested that the precipitation is really 100 to 200 mm. higher than is indicated by the rain gauges the vapourisation is about 740 to 800 mm. or 34 to 38 per cent. of the precipitation.

The maximum and percentages of runoff at the time of rain storms, which can reach 105 mm. in 6 hrs., are noticeably lower in the Melera valley than in the Sperbelgraben and still more so when compared with those of the Rappengraben. The humidity of the soil at the beginning of the rain, which the previous quantity (of rain) allows us to determine approximately, controls to a very large extent the maximum the runoff reaches. If one subtracts from the runoff during a storm the normal quantity which would run off during a sudden heavy shower one obtains a surprisingly low runoff percentage, which increases with the density of the precipitation and also with the preceding quantity of rain.

For general rains and rainy periods the effect is rather less noticeable. The greatest previous amounts and the runoff percentages, in so far as one only considers the action of the rain and subtracts the preceding quantity, rises with the quantity of rain that falls and also with the preceding quantity. With the same fall of rain it is not nearly as high in the Melera valley of which the soil is light as it is in the Emmenthal where the soil is less permeable.

The thaws and meltings of snow are not particularly marked in the Melera valley because the catchment only has a range of elevation of 700 m. Thus the temperature, the forms of precipitation, etc., with regard to snow conditions very rarely show large differences within the small range of elevation.

The melting of the snow, pure and simple without precipitation can sometimes cause a maximum runoff as high as 170 l.s./km^2.

The transport of solid matter (erosion) as calculated during the 10 years 1934/35 to 1943/44 was 87 m^3 per year per km^2 as compared with 83 m^3 in the Sperbelgraben and 145 m^3 in the Rappengraben.

The amount of underground water is explained chiefly by the relation that exists between runoff and infiltration. In the Melera valley the runoff is less than in the Emmenthal and the infiltration must therefore be greater. The continuity of the underground water during dry periods is in consequence much more favourable at Melera than in the well wooded Sperbelgraben. Periods of dryness preceded by a wet period are accompanied by a water table noticeably more regular than those where the dryness has been merely interrupted by a rain. The water table sinks a little more quickly if the dryness occurs in summer than if it is in winter. During typical periods of good weather one can say also that the daily fluctuations of runoff are in inverse proportion to the effect of the temperature on evaporation and transpiration.

The subsequent effect of the preceding precipitation on the underground water has been determined during storms, general rains, and dry periods. If one examines the effect of wet or dry winters on the water table of the following summer one finds that the soil of the Melera valley can store up to 500 mm. of water of the precipitation, *i.e.*, 500,000 m^3 p. km^2 in order to supply it more slowly to the springs and the pools in the streams.

The better springs are found in the upper parts of the Melera valley where the moraine or deposits on the gneiss are the most frequent. Three of the biggest springs furnish 30 to 50 per cent. of the total flow measured at the gauge when the water table is low or the flow is poor.

We have been able to establish for certain that the destruction of forests such as those that used to be in the Melera valley have had consequences much more serious on the "flysch" and the mica schists, than on the "nagelfluh" such as is found in the Emmenthal.

The research done in the Melera valley has given a series of results which are very important for the advancement of hydrology. But it has not been possible up to now to determine the effect of the growing of plantations on the water complex of the valley, because the first 5 years of the decade have been rather wet and the second 5 years rather dry. It is almost impossible to find 2 years

completely comparable. Among the hundreds of storms or general rains, we can only find two which were comparable and of which to make an acceptable comparison of volume, density of precipitation, previous humidity of the soil, initial water table, etc..

It has not been possible to establish the effect of a vegetational cover on the water complex under comparable conditions to the same precision as was possible in the Sperbel and Rappengraben. It is of the greatest importance for the better solution of the problems of torrent training and of the afforestation of mountainous country that similar research should be carried out in regions of "flysch" and mica schist.

ENGELHARDTIA IN PLEISTOCENE OF KASHMIR

By G. S. Puri, M.Sc., Ph.D.

*(Department of Botany and Geology, University of Lucknow)**

SUMMARY

1. The paper describes a fossil leaflet of Engelhardtia colebrookeana, which was collected by the author from the Karewa deposits of Kashmir at Laredura, in the Pir Panjal Range.

2. A comparison of the past and present distribution of this species shows that the valley at one time during the Pleistocene was occupied by rain forests.

3. A detailed past and present distribution of the genus is given and it has been pointed out that whereas the genus with numerous species was best represented in Southern Europe during the Miocene times it witnessed a decline during the Pliocene and by the Pleistocene Period it had become extinct from this region where it is unrepresented at the present time. On the other hand, as many as 15 distinct species of the genus are represented in the modern flora of south-eastern Asia from where a single fossil species has been discovered. From the above evidence it is concluded that the genus was more widely spread during the past than it is to-day.

Introduction

That the study of fossil plants elucidates the problems of origin and distribution of forest trees was brought forward by the author (*Puri*, 1945*d*) last year. In the present note it is intended to supplement those observations and to show that palaeobotany can render useful help to the forester in drawing conclusions regarding the distribution of his forests. Incidentally one may point out that ecological principles which are helpful in forestry practice are based upon the effects on vegetation of climate and soil for an accurate study of which the past history of the vegetation is as necessary as composition of the present plant communities.

The family Juglandaceae is represented in the Pleistocene (Karewa) flora of Kashmir by two important modern genera, namely, *Juglans* and *Engelhardtia*. Of these *Juglans* is still growing in the Kashmir Valley while *Engelhardtia* has since the Pleistocene migrated to the outer Himalayan ranges, in response to changed climatic conditions brought about by the uplift of the Pir Panjal Range, by at least 6,000 ft., towards the close of the First Interglacial period. Fossil leaves and fruits of *Juglans* are described from rocks ranging in age from Eocene to the Pleistocene, but, so far as we know, the present discovery of *Engelhardtia colebrookeana* from the Karewa deposits of Kashmir is probably the first Pleistocene record of the genus. However, as many as 15 distinct species are known from Tertiary horizons of Southern Europe and North America. Quite recently Oishi (1936) has described *E. Koreanica* from the Palaeogene of Japan and this is the first record of the genus in the Tertiaries of Asia.

Our fossil leaflet, which is described in the following few pages, was collected by the author in 1940 from the Karewa beds at Laredura (alt. 6,000 ft.; lat. 34° 7′; long. 74° 21′), in the Pir Panjal Range, Kashmir (*plate* 48, *fig.* 1). The plant-bearing outcrop, to

**Temporary Address*: University College, London.

Fig. I.

Fig. II.

G. S. P., Photos. x ca. 5

which De Terra and Paterson (1939) have assigned a Pleistocene age, has yielded a rich fossil flora comprising mostly of broad-leaved trees and some conifers. Modern representatives of most of the fossil species are, at the present time, found in the outer Himalayan ranges (*Puri*, 1943, 1945*a*). The flora also includes a few temperate plants which are still found in the Kashmir Valley (*Puri*, 1945*b*). A detailed account of this flora is outside the scope of this note, which is devoted only to the description of *Engelhardtia*.

I am highly indebted to Professor B. Sahni, D.Sc., F.R.S., for encouragement and helpful criticism of this note.

To the Vice-Chancellor, University of the Panjab and Principal Jodh Singh of the Khalsa College, Amritsar, I am grateful for a research scholarship for work on the Karewa fossils. I also wish to thank the authorities of the Lucknow University for the award of research fellowship.

Description

Order—Juglandales.
Family—Juglandaceae.
Genus—*Engelhardtia* Lesch.
Engelhardtia Colebrookeana Lindl.

(Photos 1–2 in plate 48).

A single leaflet belonging to this species, is illustrated in the natural size photograph (*plate* 48, *Fig.* 1). It is almost complete, excepting on one side towards the base, where it is slightly broken. The lamina is linear-oblong in outline and measures 3·55 inches long by 2.05 inches in the broadest part, which lies midway between base and apex. The margins are entire.

The venation is strict-pinnate and reticulate, though it exhibits a faint tendency to become pinnate-looped near the margins. It consists of a strong midrib and 6 to 7 pairs of laterals. The midrib has left a fairly deep groove in the fossil, which on comparison with a modern leaflet of this species seems to be an impression from the lower surface of the leaflet. It gives off on either side 6-7 strong secondaries nearly half as thick as the midrib, at acute angles in an opposite and alternate manner. The secondaries give off near the margins one or two branches, which tend to form simple loops. Tertiary veins arising from the opposite laterals anastomose to form large meshes of different shapes and sizes. A few rectangular meshes formed by the tertiaries, which are of the same calibre as some smaller branches of the laterals, appear in *Fig.* 2, *plate* 48 as if they are forming a series of superposed loops. In a part of the leaflet enlarged to five diameters in Fig. 2 there is seen a finer reticualtion, which consists of a close net-work of small polygonal meshes.

Our fossil is identical in all respects with the leaflets of *Engelhardtia Colebrookeana* Lindl., a small deciduous tree of the Sub-Himalayan tracts and low valleys of the Himalayas.

Small bits of the organic matter seen in Fig. 2 were macerated but unfortunately they were too poorly preserved to yield any cuticular preparation.

Number of specimens	One
Occurrence :	Laredura at 6,000 ft., Pir Panjal Range, Kashmir.
Collection :	G. S. Puri, 1940.
Registered No. of figured specimen	L. 574.

Past Distribution of the Genus

The genus *Engelhardtia* seems to have been widely spread during the Tertiary period in Southern Europe and North America. Out of the 16 species of *Engelhardtia* so far known only four *E. purvearensis* Berry (*Berry*, 1930, *pp.* 60-62), *E. mississippiensis* Berry (*Berry*, 1912, *p.* 236), *E. Ettingshauseni* Berry (*Berry*, 1916, *p.* 185) and *E. detecta* Saporta (*Saporta*, 1862-73) are recorded from the Eocene rocks. The first three of these were discovered from North America and the fourth species came from Southern Europe.

From the Oligocene rocks of Southern Europe five species confined to this region have been discovered. Excepting *E. detecta* Saporta (*Saporta*, *loc. cit.*) which is found both from the Eocene and the Miocene rocks of Southern Europe, and *E. Brongniarti* Saporta (*Saporta*, 1865, *p.* 199) which extends also to the Miocene, the other three species—*E. vera* Andrae, *E. ultina* Saporta (*Saporta*, *loc. cit.*) and *E. atavia* Saporta (*Saporta*, *loc. cit.*) have a restricted geological distribution.

During the Miocene times the genus seems to have been at its climax in Southern Europe. Most of the species, excepting *E. Brongniarti*

Saporta, which has been recorded both from the Oligocene and the Miocene and *E. detecta* Saporta which extends from the Eocene to the Miocene, are exclusively confined to this horizon. The other Miocene species which include *E. obscondita* Saporta (*Saporta, loc. cit.*); *E. bilinica* Ettingshausen, *E. decora* Saporta (*Saporta*, 1863), *E. Fritschi* Schlechtendal, *E. Hassencampi* Heer, *E. oxyptera* Saporta (*Knowlton*, 1919 *p.* 254) and *E. serotina* Saporta (*Saporta, loc. cit.*) seem to have had a restricted geographical distribution as all the known species were discovered from Southern Europe.

The only Pliocene species is *E. Brongniarti* Saporta which is again known from Southern Europe.

In addition to these European and American species *E. Koreanica* Oishi (*Oishi, loc. cit.*) is known from the Palaeogene of Korea.

Modern Distribution of the Genus

The family Juglandaceae with 6 genera and about 40 species of modern plants is at the present time found in the Northern Hemisphere, mostly in warmer parts of the temperate zone. However, it also extends to the tropical regions of Eastern Asia and occurs in China and Japan.

The genus *Engelhardtia* with nearly 15 modern species is at the present time confined practically to the south-eastern regions of Asia. The only species that occurs outside this monsoonic region is *E. Oreomunnea* which grows in Central America. The genus extends from the North-west Himalayas through Burma, and Java to the Philippines and China.

In the Himalayas we have nearly half a dozen species, of which *E. spicata* grows in the sub-tropical region from Nepal eastwards to Bhutan at an altitude of 6,000 ft. and has also been recently reported from Kumaon; it extends eastwards through Manipur, Assam and the Khasi hills to further east in Malaya, Java and Cochin China. *E. acerifolia* is found in the Sikkim Himalayas between the altitudes of 1,000 and 5,000 ft. and extends through the Khasi mountains to Java, Borneo and the Philippines. *E. Wallichiana* is reported from Khasi and Jaintia hills and occurs in Singapore and Malaya, *E. serrata* and *E. nudiflora* are found in Penang and *E. polystachya* has been collected from Assam.

E. Colebrookeana with which we are specially concerned here grows in the Western Himalayas from the Chenab to Nepal, ascending to an altitude of 6,500 ft. In the arid hills of Kumaon, Garhwal and along the Chenab it is common and also flourishes in the Siwalik Hills. It is recorded from the Punjab at Hoshiarpur, Kangra, Chamba and Bashahr and was collected from Jaunsar. It is interesting to note that the species is not known from the Kashmir Valley, the northern slopes of the Pir Panjal Range, or the southern slopes of the Main Himalayas where it seems to have occurred during the Pleistocene, nor in the Murree Hills. Outside India this species has been recorded from China.

In addition to *E. spicata* and *E. colebrookeana*, three other species *E. apoensis* Elmer, *E. subsimplicifolia* Merrill and *E. parvifolia* C.DC. are known from the Philippine Islands. *E. lepidota* Schlechter grows in New Guinea and *E. Esquirolii* Leveill is confined to China. One other species *E. rigida* Blume is reported from Java.

Discussion

A comparison of the past and present distribution of the known species of *Engelhardtia* reveals that whereas the genus was best represented in Southern Europe and flourished in North America in the past it has now become extinct in the former region, and except for a single species of *E. Oreomunnea*, which has a restricted geographical distribution in Central America it is unrepresented in the New World. On the other hand the modern species of *Engelhardtia* are at the present time, confined to the south-eastern parts of Asia, where excepting for a single record of the occurrence of *E. Koreanica* in the Palaeogene of Japan, the genus is not known to have formed a part of the Tertiary vegetation of Asia. This may indicate that the genus had a wider geographical distribution in the past than it has at the present time.

As many as 9 species are known to have flourished in Southern Europe in the Miocene times and the available data seem to indicate that the genus began to show a decline in this region during the later part of the Pliocene and had become totally extinct in Pleistocene times. Whatever causes may have led to the extinction of the genus in Southern Europe after the Miocene, one thing seems to be fairly certain, namely, that extermination of the

several species was probably brought about during the early Pleistocene times. The Quaternary Era, as we are told, witnessed tremendous changes of climate and altitude in the Northern Hemisphere when vast areas of Europe and America were under the spell of polar ice. The four Glacial Periods in these regions, as also in other glaciated tracts, were separated by three Interglacial Periods with relatively warmer climates and less frigid conditions. A large number of plants which were then growing in Northern Europe migrated towards the south under the influence of frigid conditions and some of these, whose relatives are found fossilized in Northern Europe, still survive in the Mediterranean countries. But those species, which were then growing in Southern Europe could hardly migrate further south as they were separated from the southern countries by the wide barrier of the Mediterranean sea. It must probably be some of these species which after surviving the refrigeration started an eastward migration through the Mediterranean regions to the temperate Himalayas and other Asiatic countries, which had now become favourable for the growth of such species. A review of the modern distribution of a large number of Temperate Himalayan species which extend westwards to Southern Europe may furnish similar evidence but a detailed discussion of this topic in this note is out of question.

It may, perhaps, be said with some justification that the numerous species of *Engelhardtia*, which were represented in Southern Europe during the Miocene and the Pliocene, probably spread to the Himalayas and further east in Malaya, Java, the Philippines and China during the early Pleistocene times. This contention seems to find some support from the fact that only one species of *Engelhardtia* is known from the Pliocene rocks of Southern Europe and the Pleistocene deposits of this vast continent have so far not yielded any species belonging to this genus.

Although with our present state of knowledge regarding the Tertiary flora of India it is impossible to say whether the genus *Engelhardtia* existed in this country during the Tertiary times, we may say with some confidence that the existence of *Engelhardtia Colebrookeana* in the Kashmir Himalayas is perhaps as old as the early Pleistocene; and as already said this genus may have spread to further India, Java, the Philippines, etc., through the Himalayan route during the Pleistocene.

The presence of *Engelhardtia Colebrookeana* in the Karewa deposits at Laredura is in harmony with the view that the Kashmir Valley at one time during the Pleistocene was occupied by rain forests, which have now migrated to the outer Himalayan ranges by the uplift of the Pir Panjal Range (*Puri*, 1943, 1945*a*, 1945*b*, 1945*c*).

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SOIL CONSERVATION IN BENGAL *

By Y. S. Ahmad

(Divisional Forest Officer, Darjeeling Division, Bengal.)

1. Experiments on Soil Conservation by the Imperial Council of Agricultural Research at Shantiniketan

Under the directions of Dr. P. M. Sen of Sabur agricultural college, Babu P. Sen started some soil conservation work on the *danga* land near Shantiniketan as a pioneer. The whole scheme is financed by the Imperial Council of Agricultural Research. A series of low embankments were constructed about 2 ft. wide at the base, 1 ft. on op and about 1 ft. high at the end of one year. These were constructed on the tophill, just above the head of the gully erosion, to hold the water running off from the hill into the gully. The *bunds* were turfed. As the runoff was checked, the rain-water passed into the soil and a fair growth of *Desmodium*, with long running roots, was noticed on the ground. If the *Desmodium* and grass could be saved from grazing or even cutting for some time till they got matty, soil would be reformed by the organic action of their roots and within a few years the bunded area would afford fair grazing.

On the ridges along the gullies, seedlings of *Acacias*, *Dalbergia* (*sissu*), *Albizzia* (*siris*), *Tectona* (teak) and other plants had been planted.

Adjoining this area, a *bund* constructed by the special officer, tanks, for Birbhum district, for collection of water in a reservoir was seen. A sluice gate was constructed for the overflow. The water collected in the reservoir was for supply to Shantiniketan and for irrigation of the adjacent paddy fields.

Suggestions for improvement.—Although the technique is not ideal, the work has been started on the right lines. As soil erosion is caused by the rain-water running off rapidly, the *bunds* should be started from the top of the hill in concentric rings. The *bunds* should run accurately along the contour. The first one may have a radius of about 300 ft. or less and the second one another 300 ft. or less apart according to the area of the ground to be covered and its configuration. The *bund* should be completely closed so that all the rain-water on the area can be held and forced to seep through the ground. If the rainfall be heavy and tends to break the *bund*, one or more outlets should be constructed at the lowest points. The channel should be heavily manured and some thick matty grass grown artificially so that it may not be washed away by the rush of water and no erosion can take place. The ideal size of the *bund* is 9 ft. at the base, 4 ft. high at the time of construction and 1 ft. wide at the top. One or more places for taking the cattle in and out of the area should be constructed higher than the level of the *bund*. The *bund* should be turfed. The ground within the *bund* should be ploughed or lightly hoed to facilitate seepage of rain-water and this alone will considerably encourage the growth of grass on the area.

The ridges along the gullies should be covered with cut grass or leaves held to the ground by bamboos, branches or weights. These will protect the soil against the excessive heat of the summer sun and also hold the rain-water and allow it to soak into soil slowly. The ridges should then be thickly planted up

*Paper presented at the 7th Silvicultural Conference (1946), Dehra Dun, on item 4—Contour bunding and trenching as counter erosion measures.

with seedlings of fast growing trees not farther than 1 ft. apart. The crowns of these plants will protect the soil from heavy showers of rain and their roots will bind the soil which will later be over-grown by some sort of soil cover. As the seedlings grow bigger they will be gradually thinned out but the soil should never be fully exposed to the sun and the rain.

Below the gully, the soil carried down from the top of the hill by the rain is deposited into a fairly level mass. If grass is allowed to grow matty and consolidate this soil for a few years, such areas can soon either be brought under cultivation or under fodder crop according to local requirement.

Grass should also be allowed to grow on the banks of the reservoir to hold the soil. On top of the *bund* some trees can be planted. Along the edge of the water some lotus and reeds may be grown to break the ripple in the reservoir and prevent breach of and erosion on the banks.

II. The extent of Soil Erosion

The following figures have been taken from the Agricultural Statistics of Bengal for the year 1941-42 (which is the latest issue) :—

District	Area in Acres					
	Forests	Not available for cultivation	Other uncultivated land excluding current fallow	Current fallow	Net area sown during the year	Total area
Birbhum ..	—	299,158	182,163	20,726	613,300	1,115,347
Burdwan ..	—	441,779	242,408	344,533	723,600	1,752,320
Bankura ..	—	390,427	349,494	324,351	630,000	1,694,272
Midnapore ..	—	806,806	553,497	254,157	1,780,100	3,394,560
Dacca ..	37,697	193,290	21,900	41,513	1,462,400	1,756,800
Mymensingh ..	46,295	1,156,400	119,917	264,520	2,398,000	3,985,132

(Figures for Dacca and Mymensingh districts have been quoted for comparison.)

In West Bengal, the forests are included in areas 'not available for cultivation.' From the forests visited at Chakgopalpur in Burdwan, Dhaban and Khayerbani in Bankura and Barbeta in Midnapore, it is evident that in these districts, soil erosion is as common in the forest areas as in the *danga* lands. The current fallows are so poor in soil that they can only be cultivated about once in three years. Even if the *danga* land under 'other uncultivated land excluding current fallow' is excluded for consideration it is obvious that in Bankura and Burdwan are the worst eroded districts. Erosion is not serious in Jhargram sub-division of Midnapore district but as one proceeds north towards Bankura, erosion is more and more conspicuous. Even in Bankura and Burdwan erosion is more serious towards the approaches to the coalfields, it is also significant that the eroded areas in Bankura and Burdwan districts exceed the areas cultivated every year (vide table below).

Area in Acres

District	Total area	Cultivated area	Eroded area
Birbhum ..	1,115,347	613,300	319,884
Burdwan ..	1,752,320	723,600	786,312
Bankura ..	1,694,272	630,000	714,778
Midnapore ..	3,394,560	1,780,100	1,060,963

III. The Cattle

The statistics of livestock on the next page (578) have also been collected from the Agricultural Statistics of Bengal for the year 1941-42, based on the cattle census held in 1940.

Livestock Statistics of Bengal (1941-42)

			Birbhum	Burdwan	Bankura	Midnapore	Dacca	Mymensingh
Cattle	Males ..	1. Breeding bulls	1,1,942	3,619	3,575	10,953	14,404	29,475
		2. Working bulls and bullocks	206,082	185,622	217,536	579,167	380,876	760,258
		3. Not in use for breeding or work.	30,706	26,010	21,259	48,756	15,672	109,079
	Females ..	1. Breeding cows.	228,078	344,090	300,945	607,122	431,164	745,593
		2. Cows used for work only ..	371	282	303	3,798	57,007	192,859
		3. Not in use for breeding or work	1,261	959	566	6,157	10,147	41,838
	Young stock ..	.. .. ..	149,901	222,188	185,272	483,586	288,407	602,426
		Total cattle	618,341	782,770	729,456	1,739,539	1,191,777	2,481,528
Buffaloes	Males ..	1. Breeding bulls	101	1,374	581	1,124	35	2,105
		2. Working bulls and bullocks	23,626	50,172	43,577	30,020	1,433	24,695
		3. Not in use for breeding or work.	428	1,515	1,193	3,890	133	1,335
	Females ..	1. Breeding cows	5,298	9,764	35,350	21,782	746	14,191
		2. Cows used for work only ..	644	267	134	390	885	12,847
		3. Not in use for breeding or work	71	169	66	251	—	1,903
	Young stock ..	.. ..	2,756	7,195	21,169	16,094	950	10,884
		Total buffaloes	32,924	70,456	102,070	73,551	4,182	68,960
		Total Bovine population ..	651,265	853,226	831,526	1,813,090	1,195,959	2,550,488
Sheep	....	....	80,575	71,419	63,140	42,526	918,980	37,713
Goats	....	....	243,205	261,632	305,333	386,614	272,193	625,769

(Figures for Dacca and Mymensingh districts have again been quoted for comparison.)

The Census figures for 1945 are not yet available. It is therefore assumed that the proportion of cattle in the various districts will be approximately the same. Although no one can vouch for the reliability of these figures, they give a fair comparison of the cattle population in these districts.

The proportion of cultivated area, to the total number of working cattle and buffaloes in the districts and the total population are given below :—

District	Cultivated area in acres	Number of working cattle & buffaloes	Total Bovine population	Total population persons
Birbhum ..	613,300	230,723	651,265	1,048,317
Burdwan ..	723,600	236,343	853,226	1,890,732
Bankura ..	630,000	261,550	831,526	1,289,640
Midnapore ..	1,780,100	613,375	1,813,090	3,190,647
Dacca ..	1,462,400	440,301	1,195,959	4,222,143
Mymensingh ..	2,398,000	990,659	2,550,488	6,023,758

(Figures for population have been taken from the Census Report of 1941).

It is evident that in Western Bengal districts the proportion of cattle to population is high. Some of them are perhaps used as draft animals and not for cultivation. What is however definitely indicated is an inquiry to find out if the number can be reduced, and the stock improved in quality which can be well looked after by improving the fodder and grazing. A smaller number of good cattle will require less fodder but give much better service. The feasibility of cultivation by tractors under a co-operative system may also be investigated.

IV. General

Causes of erosion.—Soil erosion is caused by removal of soil cover. The heavy rain during the monsoon hits directly on the soil and washes it away. The removal of soil cover may be due to disafforestation, or excessive grazing, or burning of the soil cover in forest areas. In short, with the wrong use of land that is when a land, which by its nature is fit only to grow a forest, is cleared of all forest growth and is cultivated without any artificial measures to conserve or improve the condition of the soil, soil erosion sets in.

Effects of erosion.—There are many ill effects of soil erosion. The eroded area loses all top soil and is unable to retain moisture and allow any vegetation to grow on it. The low land in the neighbourhood first gets the fertile top soil or even vegetable manure commonly called soilt but after a few years, as erosion proceeds the subsoil, sand and pebbles are carried down and deposited on the low land which gradually but steadily loses its fertility. This effect may be observed miles away from the source of the erosion depending on the rapidity of the flow of water carrying the soil down. The fine top soil from the eroded area is also first pasted on the bed of the river like cement which completely blocks the pores on the soil and stops seepage. Later as sand and stones are brought down by heavier erosion, they are deposited on the bed of the river which gradually rises. Consequently the river is unable to hold the same volume of water as it did before and during the heavy rains of the monsoon, the banks of the river are invariably overflooded causing indescribable damage to the crops and the villages. Due to erosion in the catchment areas of rivers a hard crust or rock is exposed on the ground, the monsoon rain quickly runs off into the stream, the seepage in the catchment area is so badly reduced that the springs get no supply of water, the rivers are flooded in the rains and become high and dry for the rest of the year.

V. Conclusion

Soil erosion in Birbhum, Burdwan, Bankura and Midnapore districts in Western Bengal has assumed serious proportion. It has been caused by the wrong use of land for years. It will also take a long time before the land can be renovated to a productive condition.

From the forests visited it is obvious that soil erosion is common even in these areas. Forests can prevent soil erosion only when the floor is covered with a thick layer of leaves which acts as a sponge, retains the rain water and allows it to soak down into the soil to feed the springs and prevent quick runoff. A soil cover of grass or low shrubs, like the paddy plants on the fields, will also prevent soil erosion. But the forests in West Bengal have neither a layer of leaf nor a soil cover on the floor. It might have been caused by excessive grazing, annual burning with a surface fire and too frequent clearfelling, thus exposing the soil to the full effects of the sun and rain. Regulation of felling under a proper working plan with a much longer rotation will not be sufficient to conserve and rebuild the soil. Grazing will have to be stopped and the forests will have to be vigorously protected against fire. Nature's method of soil conservation is the same. It was noticed at Chakgopalpur in Burdwan and in the Khayerbani forest in Bankura that many thorny plants like wild plum and *shcora* were growing on the newly deposited soil, specially below the gullies. The cattle could not browse them on account of their spiky thorns. Grass was coming up under their protection, first to consolidate the loose sand and then to rebuild the soil. Even in parts of the *danga* land, as seen at Ramsagar, wild plums were growing in pockets which could hold some rain water. They prevented grazing and grass was seen coming up.

It is therefore obvious that along with engineering works like the construction of contour *bunds*, grazing will have to be drastically controlled. If the cattle are to be kept away from the forests, grazing will have to be provided on the *danga* land. If the soil in the forest areas is not conserved, they will also be reduced to unproductive *danga* land and the whole country will be rendered into a bare waste. The only solution therefore appears to be to conserve the trees and the soil in the forest and to grow fodder crops under the protection of contour *bunds* on the *danga* land.

Although the Bengal cultivator is conservative like his confreres in other parts of the world, he is intelligent. He will take to new methods if he sees that they are to his advantage. Government will therefore be well advised to start a series of demonstration farms on the *danga* lands in each of those four districts in West Bengal. Contour *bunds* should be erected as indicated by Dr. Shuhart, the soil within the enclosed area should be ploughed or lightly hoed to facilitate the seepage of the rain water into the soil and grass and other fodder crops should be grown to find the species most suitable to the locality and to obtain their seeds for propagation. The ridges along the gullies should be thickly planted up with fuel trees. The embankments of roads and railways should be reduced to a maximum slope of 2 in 1 and should all be turfed. The grass on the unmetalled portion of roads should never be scraped off.

Above all, the people should be made conscious of the serious effects of soil erosion and taught the simple methods by which the soil can be conserved, if applied in proper time. If the rain be insufficient, the fields can be irrigated from tanks and wells; if the soil is deficient in certain chemicals, they can be made good by artificially introducing these chemicals into the soil; but if there be no soil left and the ground contains only rock or an impervious crust, no cultivation of food crop or fodder crop is possible until the soil is reformed. The cultivator knows full well that when the rain water is allowed to percolate over his paddy field surrounded by a low *bund* or "aisle" it irrigates the plants and then goes out as clear water. Any soil which it might carry is held up by the paddy plants. If he is shown how the same process can be repeated on the *danga* land, there is no reason why he should not take to it as enthusiastically as he does for his paddy fields.

CONTOUR TRENCHING

By W. D. M. Warren, I.F.S.

(*District forest officer, Ghumsur North Division, Orissa.*)

I have followed with interest the recent correspondence in the *Indian Forester* concerning contour trenching. The correspondence commenced with criticism by Sir Herbert Howard and Sir Harold Glover, that contour trenching is expensive. Although it may be necessary outside reserved forests to be expensive in order to demonstrate the value of such methods to the *ryots*, as Dr. Gorrie points out, that hardly excuses us for being too expensive inside our forest areas. He must not let our enthusiasm for contour trenching blind us to the necessity of seeking an economic return for the money spent.

Let me give an example of where enthusiasm outran discretion.

The example comes from America where in the usual thorough American fashion the local foresters decided to construct trenches capable of holding twice the amount of water which could ever fall on the area in any one storm. They then planted the hill with trees, conifers, I think. Within five years the vegetation had increased so luxuriantly that the runoff was being held up completely by vegetation alone and the trenches were no longer needed. Had the foresters there been a little more cautious, had they trusted Nature herself a little more to come to their aid with the stimulated growth to hold up the runoff they could have saved much money.

In Bihar, I have seen the same sort of thing happen. Trenches have been dug far too close together and in other cases far too wide and deep, some of them three feet wide and three feet deep; almost deep enough to form an effective barrier against the Jap invasion which fortunately never materialised !!

Deep trenches in any case are unnecessary as well as expensive for holding up the runoff as the water is carried down too deeply into the subsoil. What is really wanted is to keep the runoff seeping down the slope within one foot of the surface in order to stimulate surface rooted species such as grasses. Once vegetation penetrates deeper than this, its survival in the subsequent hot weather desiccation is more or less assured. I can say this with some certainty as in all my soil moisture tests taken in the hot weather the moisture content at one foot depth, or more below the surface, was well above the wilting point which is about 5 per cent. It was only in the first foot depth of soil that the moisture content fell below that point.

Let it be said in defence of the enthusiast that eroded areas look so desloate, so devastated that one is apt to spend far too much rather than too little on them in order to restore the soils fertility; but we must be patient and realize that contour trenching is only a means to an end, not an end itself; the end being to hasten the establishment of a complete vegetative cover—the ideal way of holding up the runoff. For, however effective trenches may be in holding up the runoff at a particular contour, they cannot in themselves hold up the rain from running down the slope in between the trenches—that function, so necessary for trees planted in between, can only be performed by the vegetation induced and stimulated by the trenches. It follows from this, that we should never plant up an area until the vegetation in between trenches is complete, and that may mean waiting for several years after the trenches have been constructed. For, once the vegetation is complete, 90 per cent. of all downpours can be held up by the vegetation itself—a Panjab runoff experiment in the Upper Doab proved that—a rainfall of 10 inches in 19 hours being effectively held up to that percentage by grasses alone. I scarcely think there are many downpours, experienced in India, of greater intensity and amount than that.

How much money then should we spend on contour trenching, in our forests ? Unless plantations are being established for political reasons, where money is no object and where economic returns are not insisted upon, I think, we foresters should insist upon a three per cent interest on all the money spent.

In our calculations we can, I think, legitimately ignore the expenses of the local protective forest staff, for they are established there in any case, and we are only giving them

extra work to do. But the expenses of extra staff engaged specifically for the contour trenching should be debited to the work and not to the general administration.

Contour trenching of earth work where the trenches are 2. ft. broad by 1 ft. deep, and the wages six annas a day, should not cost more than Rs. 100 per mile including the cutting through soft rock in places and the cutting out of tree roots. At this price, trenches, placed 70 yards apart, would cost Rs. 4 per acre.

Without working out the economic returns, I used to reason out that if I could afford to pay Rs. 4 or more for weeding plantations in the heavier rainfall areas of Saranda, I could afford to spend that amount on contour trenching in more arid areas where weeding costs could be saved. Thus I could not be tempted to place contour trenches closer than seventy yards apart; Nature with her vegetative cover must do the rest!

In another case where we had an existing forest of about 1,000 acres, set in the midst of an area where fuel and timber was scarce, I actually worked out on the contour map how far apart my trenches must be, their lengths and their costs to give me the prescribed 3 per cent. compound interest on the modest assumption that the volume of timber and the revenue would be doubled as the result of the trenching—a very modest assumption indeed. On the other hand where political considerations demand the rehabilitation of devastated forests in the shortest possible time, economic returns are not the chief consideration as Sir Herbert Howard points out in his *Post War Policy* of village forest expansion. Of course in areas like that where timber is very scarce we could argue that we were justified in completely ignoring economic considerations, for the public weal in order to use up the surplus from our main reserves rather than to hand it over to other departments to spend where economic considerations did not prevail.

Having dealt with the expense of contour trenching let us now turn to another aspect of it, namely the length of time we may have to wait after the trenches are dug before planting up is done. We follow Nature in this respect which decrees that the grasses must come in first and then the trees—considerations of runoff give the reasons why this is so. In one case in the Bijaipur, Khurchutta forests of Santal Parganas, Bihar, a very badly eroded area was contour trenched in 1938. Only a few stunted *khair* (*Acacia catechu*) *asan* (*Terminalia tomentosa*) and *Mowhua* (*Bassia latifolia*) up to ten feet high were to be seen on the devastated sheet eroded medium slope, about three hundred yards long. Three trenches were put in, one at the top just under the plateau, one in the middle and one near the bottom. The area was then left until the grasses filled in completely before planting was to be attempted. In 1943 I saw the area again and one could scarcely believe it was the same area. The trees looking luxuriant had put on vigorous growth and the grasses, chiefly spear grass had very nearly covered the area. Grazing in the intervening years had not been completely stopped, so it was decided to wait a little longer before commencing the planting. The local forest guard was transferred from three miles away and ordered to remain there all through the monsoon to prohibit grazing altogether. If he did not do so, I promised him a beating! I must have frightened him pretty badly as he caught and reported several people that rains for illicit grazing. When the area was again examined next cold weather the grass cover was complete, *khair* regeneration was coming in, and at the bottom of the hill from a few isolated *sal* (*Shorea robusta*) trees, *sal* regeneration was also showing itself. From these indications, the area was judged to be fit for planting up and I have no doubt that this has been done since. Thus the area had taken six years to become fit for planting. It would have taken less had grazing been rigidly prohibited from the beginning.

It is worthwhile mentioning the difficulties experienced in keeping the trenches under repair on this long slope. While the two top ones required few repairs during the monsoon, the bottom one was continually bursting its parapet. What had been trickles of water in the *nullahs* near the top, had become swollen streams two or three feet across at the foot of the hill, and it was quite evident that the trench was totally incapable of holding up so much water. In such cases it is wiser to allow the bigger streams to slip through, and to be content with holding up the general runoff of the slope only, and one or two of the smaller streams.

In gully eroded areas, it will be sufficient if one trench is dug along the top of the escarpment, with the next one dug below on the more level area. None should be dug on the sides of the gullies as the work becomes too expensive. Vegetation will commence below, and gradually work up the slopes of the gullies.

Value in Existing Forests

The value of contour trenching in existing forests has been so much emphasised by me in connection with the Bamiaburu trenching experiment that I need scarcely repeat it here. We must wait patiently for research to indicate the precise nature of the improvement in quality and rate of growth which result from such operations. In doing so I trust the research officer will not ignore the extraordinary fine regrowth in the old Santara 8, where a series of thinning experiments were laid out. The precise quality of the area originally, before clearfelling and subsequent contour trenching altered the quality, can be obtained from the surrounding untouched hill forest area, where Nature can still show on the trees, their original height before trenching induced abnormal vigorous regrowths at the ends of branches. Nature does not cover up her secrets too easily, fortunately for us!

As to the necessity of such operations, can any forester, who is keen and takes his profession seriously be content in Singhbhum while six-sevenths of Kolhan division, three quarters of Saranda, and about three quarters of Porahat are still too poor in growth to be considered fit for including in the conversion working circle? I do not suggest that the whole of such areas should be contour trenched —that would be an utter impossibility, but it is quite a feasible plan to select three or four centres in each division in which to establish a system of trenches on the Bamiaburu model with say 70 or 100 miles of trenches in each centre.

Climatic Value

Not only must the direct benefit of the water held up, on forest growth be considered, but the indirect benefit to forests over a much wider area due to climatic improvement cannot be ignored. It was Mr. Owden's and my considered opinion that four such centres in Kolhan would improve the climate and growth over the whole of the division. That opinion (it is an opinion only of course) is strengthened by the meteorological experts who tell us that contour trenching will improve the local forest climate, while a recent examination of the rainfall data for Chaibassa and Chakardharpur outside the forest for the eight years since the contour trenehing experiment first got going on a large scale, against their own and Chota Nagpur's previous rainfalls and normals lend colour to that belief. I shall deal with this, in a subsequent article. The converse, namely the desiccation of climate due to disforestation, has now been proved scientifically. So while I consider that contour trenching should find a place in all reafforestation work, its value for improving existing forest growth should not be ignored.

Cheapness of Trenching

Contour trenching in existing forests is really absurdly cheap. On Dopogarh hill in the Bamiaburu area we only had three trenches, in a height of 800 feet and in the other areas, never more than two continuous trenches on the contour. Yet the area trenched was fifteen miles long by one-half to three miles wide trenched at an original cost of only about Rs. 12,000. Mr. Ranganathan, Director of the Ranger College, Dehra Dun, on his visit in 1942, was surprised to find so few trenches. He expected them to be within a few yards of each other, misled doubtless by the Gradoni system initiated by Italy.

Expense then need not deter us from contour trenching existing forests. Naturally schemes should first be introduced in areas where the economic returns are most favourable and where the benefit to the population is greatest, that is in areas near centres of population or near to railways for transporting the produce. Thus the Damodar valley forest area, with its very convenient Central India coalfield railway running through its length, would, if contour trenched, yield excellent economic returns, quite apart from the value in checking erosion and floods and in preventing the silting up of the new dams to be erected there. Mr. Sinha's views are therefore economically sound.

Contour trenching has a great future, of that I am convinced. It is because the idea is new and possibly because of the mistakes

made in our enthusiasm for it, that it has been criticised at all. Prejudices die hard, man is instinctively on the defensive against ideas which upset his preconceived notions. However, trenching will make converts of all those who practise it—I can guarantee that the results silviculturally in localities of decent rainfall will always be better than the expectations—a real revelation of what extra water held up can do.

EXTRACTS

ROAD EMBANKMENTS AS DAMS IN HILLY COUNTRY

By M. J. Youhotsky, M.Sc. (Calif.), A.M.I.E., Aust.

(*Forest Engineer, Forestry Commission of N.S.W.*).

It is a platitude that every drop of water on the State Forests should be retarded and forced into the soil to feed the trees, or impounded and retained in pools as a source of water-supply for fire-fighting.

Construction of extraction and fire-roads presents a very good opportunity of achieving both aims by attention to damming possibilities of road embankments, if properly constructed and supplied with safe overflows.

The general desirability of this policy was formulated in the writer's article in *The Australian Timber Journal*, April 1942, and Commission's roadbuilders follow this policy wherever they can implement it easily.

One of the main difficulties in using road-embankments as dams is that generally in the coastal regions the dry stream beds swell to floods during the sharp showers, and quickly subside. The scouring capacity of such streams sometimes is well in excess of their possible usefulness as a source of water-supply, due to additional expense needed to make the flood outlet of the embankment sufficiently big to safeguard both the dam, and the road-bed against scour and washaway damage. So far as N.S.W. is concerned road-dam idea in its cheapest form could be easily exploited only in such an exceptional area as Bago S.F. near Batlow, and some other forests in Eastern Riverina district. There the rainfall is liberal and evenly-spread, the forest floor covered with sufficient litter and soil is light, rain-water soaking in and then being yielded from the soil continuously. Apart from other tableland forests and occasional patches of rain forest elsewhere, conditions are different: the country is dry, and the run-off sharp.

Generally a good policy would be to eliminate the culverts and bridges from forest road construction altogether; this however is hardly practical. Substituting an overflow dam for each crossing, we have to face the fact that each small dam capable of handling sudden floods, is of necessity nothing much but the costly—when effective—overflow structure.

A dam without an overflow is cheap and effective—provided that flood waters can be diverted well above it into a safe channel.

During a recent inspection around Bateman's Bay, an interesting feature typical of hilly coastal forest areas was observed, namely that the slopes often consist of intermittent small spurs and gullies, which must be traversed by the proposed forest roads with a certain amount of cuts and fills, pretty well balanced.

Without laying down any rules, or trying to attempt at a specification, the following suggestion is made for each road-man or forester reconnoitering for the road location in similar country, particularly when road is to be constructed, as was the position in N.S.W. for years, using bulldozers, power scoops, and trailbuilders permitting cheap excavation and shifting of dirt.

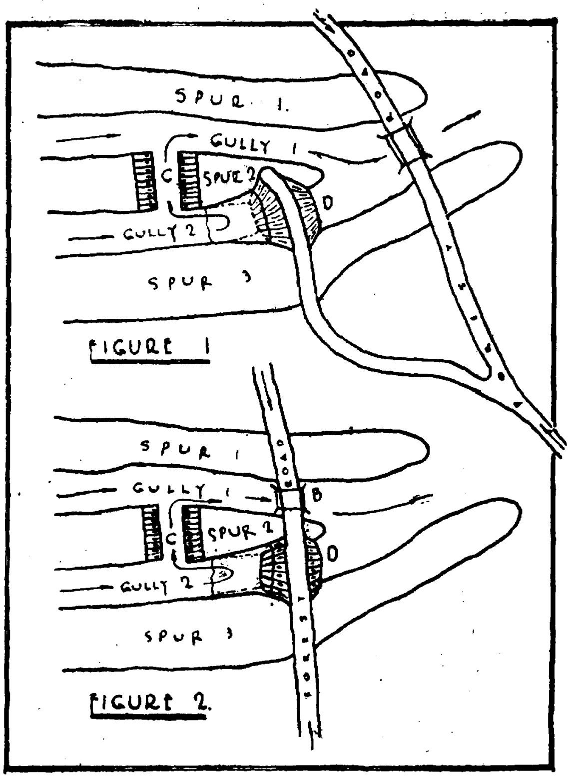
Where the road crosses a number of spurs, watch for a pair of gullies of approximately equal depth and determine their catchment areas and flood outflow, both individual and combined.

Now see diagrammatic drawing on the opposite page.

Refer to Fig. 1. If due to road alignment or crossing conditions, the road has to traverse below the tip of the middle Spur 2, a culvert or bridge of the usual type has to be built at "B," with an opening sufficiently large to take the maximum combined flood waters from the catchment areas of both gullies—Nos. 1 and 2.

A relief, or by-pass channel "C" is then excavated as far from the tip of Spur 2 as practicable, and the spoils obtained are used to construct the earthen dam "D" which will impound water. The channel to be capable of handling all flood waters of gully No. 2. A short access road to the dam will enable fire trucks to back on the dam and take water on. Without going into details, the success of such dams depends upon careful removal from the bottom and sides of the gully, on the dam site, of all top soil and vegetable

matter, grass, roots, etc. Earth fill should be of clean material laid in layers, and well consolidated. Which means that prior to excavation of the channel, the top soil, etc., shall also be removed. Top soil, thus stripped from both channel and dam sites, should later on be placed on the sides of the dam, and if conditions permit, banks of the channel, and grass sown or planted.



Wherever conditions allow of crossing as per Fig. 2, the resulting arrangement is still better, not requiring any extra road approaches to the dam and backing of truck on to it.

All remarks made for Fig. 1, hold good in this case, too.

Probable eventual siltation of ponds will have to be combated once every few years by using suitable scoops, though in some cases use of flush drains under the dam might be possible. Excavated silt traps above the dam site might also be useful.

The volume of storage obtained will depend on these factors: The slope and the depth of the gullies' bottoms, distances between the centres of the dam "D" and channel "C", permeability of the dam site, material used, and care exercised in construction of the dam, as well as evaporation conditions.

It appears that with the machine-built roads, the schemes described could be put in so cheaply that even if formation of permanent ponds is not guaranteed, the temporary storage might be of inestimable value during fire seasons, and the implementation of the proposal should be always attempted by forest road builders.

—*The Australian Timber Journal*, January 1946.

PRODUCTION OF FODDER GRASSES IN INDIA

BY MALIK FAZL HOSAIN, DIP. AGRIC. (WYE)

(Estate Manager, Imperial Veterinary Research Institute, Mukteswar).

The inadequate supply of feeding stuffs is the most important factor which stands in the way of maximum production from Indian cattle. The situation is all the more complicated, because this lack of food is telescoped with general nutritive inferiority of the existing stable fodders constituted mainly of straws from cereal and millet crops. The exigencies of the war have further revealed the abjectness of the situation; the half-famished Indian cattle have uddenly been called upon to supply the extra motive power for the increased demand of the 'grow more food campaign', and to produce at the same time more milk and milk products for maintaining the national health. It has not taken long to realize that the success of the campaign has to rest largely on how the drive for 'grow more fodder' is planned. The survey of the pre-war situation in regard to fodder-crop production had shown that by far the major portion of the arable land of the country is devoted to cash crop production and the proportion for exclusive growing of fodder-crop is neglible.

In some of the major provinces, to safeguard the requirement of livestock, the acreage under fodder-crop needs to be increased by 12 to 50 times.[1]

While there is this paucity of acreage for cultivated fodder, properly developed grass lands are few in India.

There are seemingly vast areas for grazing and harvesting grass crop which are preserved by the Forest Department[2]. Although the area is vast, Indian cattle can make very little out of forest grazing. For example, the higher Himalayan forests are practically unused, and the great belt of forests along the foothills of the Himalayas in Bengal and the United Provinces is out of reach of the cultivators. In fact, out of 43 million head of cattle in the United Provinces, only one and a half million or 3.5 per cent. make any use of forest grazing. In the Central Provinces, Bombay and Madras, where the forests are interspersed amongst the cultivated lands, grazing is comparatively better but even so, it is mostly confined to the outer fringes of each forest block. Only in the Punjab is the incidence of forest grazing heavy. Any possibility of husbanding forest grass by cutting for hay and silage-making, is precluded because of tremendous transport difficulties.

In the open expanses of the Indian plains, there are also vast areas of land never seriously used for cultivation purposes. In these so-called waste lands every year grass crops of varying quantity and quality grow. Due to the lack of proper husbanding, much of this grass quickly grows to maturity and later dries up. The top growth returns to the soil after being decomposed by rain and sun. In the following year with the advent of monsoon the old and exhausted plants are replaced by new seedlings to which they themselves have given existence and thus, year after year a constant natural replacement of herbage takes place. It is in these waste lands that suitable reclamation projects can be adopted to turn them into useful pastures and fields for harvesting grass crops.

In recent years, schemes are being considered to study the problem of mitigating the acute shortage of right-quality fodder for Indian livestock. One of these schemes is concerned with the exploration of suitable types of indigenous grasses which can be produced on large scale in the reclaimed *barani* (rain-fed) lands. Some headway has already been made in studying the composition and nutritive value of a number of widely prevalent indigenous species. These preliminary studies have revealed that there are some Indian grasses which may be considered good sources of nutrients. However, a considerable amount of research, particularly on agricultural aspects of grass production, has yet to be carried out before any final selection can be made of grass species which can be grown extensively in the diff rent regional areas of this country.

IZATNAGAR EXPERIMENTS ON GRASS PRODUCTION

For the past several years in the estate farm of the Imperial Veterinary Research Institute at Izatnagar, an investigation has been carried out with several varieties of indigenous grasses which grow widely in the United Provinces to study (*a*) the habit of growth, (*b*) the duration of life of the ley, (*c*) the yield, (*d*) the number of cuts available just at the flowering stage and (*e*) the availability of green cuts outside the monsoon periods. In order to make a comparative study, a few well-known cultivated grasses were also grown under similar environmental and cultural conditions. The varieties of grasses grown are given in the following list :—

A. *Indigenous grasses* :
1. *Jenewah* (*Andropogon ischaemum*)
2. Golden crown (*Paspalam dilatatum*)
3. *Kolukattai* (*Pennisetum cenchroides*)
4. *Bhanjura* (*Apluda varia*)
5. *Surwala* (*Andropogon contortus*)

B. *Cultivated grasses* :
1. Rhodes grass (*Chloris gayana*)
2. Guinea grass (*Panicum maximum*)
3. Napier grass (*Pennisetum purpureum*).

To grow these grasses, a uniform area of light sandy soil was selected. The area was sub-divided into plots of 1/20th of an acre each, for the eight species. Before planting the grasses, each plot was dressed with 10 mds. of well-rotted farmyard manure. In the month of July-August, 1940, as soon as the monsoon had properly set in, the roots of each species were planted at a distance of 2½ft.

1. *Animal Husbandry and Crop Planning in India* by K.C. Sen and S. C. Ray (1941). *Science and Culture,* **6,** 684-689

2. Note by the President, Forest Research Institute, Dehra Dun, in the *Proceedings of the First Meeting of the Animal Husbandry Wing of the Board of Agriculture,* India, 1933.

apart. The plots were under experimental observation throughout the period which terminated at the end of November, 1944.

During the period covered by July 1940 to November 1944, the record maintained of rainfall is given in Table I.

TABLE I

Inches of rainfall during July, 1940 to November, 1944

		1940	1941	1942	1943	1944
January	1st half	—	0.69	—	1.92	*nil*
	2nd half	—	0.66	2.95	0.06	2.32
February	1st half	—	0.12	—	*nil*	*nil*
	2nd half	—	0.25	2.34	*nil*	—
March	1st half	—	0.24	*nil*	*nil*	*nil*
	2nd half	—	*nil*	*nil*	*nil*	11.9
April	1st half	—	*nil*	*nil*	0.21	1.48
	2nd half	—	*nil*	*nil*	*nil*	*nil*
May	1st half	—	0.95	*nil*	0.20	*nil*
	2nd half	—	*nil*	*nil*	*nil*	*nil*
June	1st half	—	2.79	*nil*	0.06	0.83
	2nd half	—	0.60	7.04	4.42	1.00
July	1st half	8.43	0.23	6.52	0.57	6.25
	2nd half	13.19	1.69	6.32	6.61	6.50
August	1st half	12.49	9.61	6.78	11.33	2.41
	2nd half	5.70	3.92	6.58	10.13	2.21
September	1st half	*nil*	6.06	2.89	4.75	2.55
	2nd half	2.23	*nil*	0.75	0.50	*nil*
October	1st half	*nil*	*nil*	*nil*	*nil*	*nil*
	2nd half	*nil*	*nil*	*nil*	*nil*	*nil*
November	1st half	*nil*	*nil*	*nil*	*nil*	*nil*
	2nd half	*nil*	*nil*	*nil*	*nil*	*nil*
December	1st half	0.22	0.08	*nil*	*nil*	—
	2nd half	0.76	*nil*	0.80	*nil*	—

From the data presented in Table I, it is apparent that monsoon in Izatnagar during the course of present study usually started in the middle of June and terminated at the end of September. Practically all the grasses, which grew since the last cut in monsoon, reached the flowering stage sometime in November and according to the plan of the experiment were duly cut. As there was a long spell of dry period following the month of November, the plots were irrigated at the end of this month. The pre-monsoon crop of the different grasses was ready for harvesting at the end of March or at the beginning of April. As soon as the harvesting was over, the plots were given two successive irrigations, one, in the middle of April and the other at the end of May, to keep the sward in a good condition during the dry hot period between April and middle of June. The grass plots were hoed twice in a year, once in the month of November and a second time in the month of April.

The majority of the grasses took 3 to 4½ months to get established. *Bhanjura* and *Surwala* were exceptions; these grasses took over nine months to establish themselves. This delay might have been partly due to the relatively advanced period of monsoon when their roots were planted. After the indigenous species got properly established and with subsequent progress of growth, it was observed that like the cultivated grasses they developed the habit of growing in thick clumps. This clumpy growth was due to the method of planting by roots and leaving interspaces. Although the method permits easy hoeing and inter-culturing, it is unsuited for large-scale production of grass where the use of a mower is indispensable at the time of harvesting. A separate experiment was carried out to observe the habit of growth of the indigenous species when the grasses were grown by broadcasting the seeds. In this method of propagation, thick clumpy growth was found to be markedly less and no difficulty could be experienced in running the mower through the grass fields. The grass grown by seed, however, took relatively longer time to establish.

The results obtained of the trial during the four successive years are set out in Table II on page 599.

It may be seen from the data presented in Table II that following their plantation in the previous monsoon, *jenewah* and Golden Crown amongst the indigenous species, and Rhodes amongst the cultivated grasses, gave the maximum yield in the first year (1941). The other grasses reached the peak of their yield in the second year (1942). The yield of all grasses, excepting *jenewah* and Golden Crown, tended to fall from the third year of their stand. The downward trend became very pronounced in the fourth year. Under the environmental and cultural conditions of the present experiment, it was apparent that the vigour of the sward in the case of all grasses remained potent for a period of only three years.

Amongst the indigenous grasses, during the period ranging between 1941 and 1943 when

the sward was in full vigour, although *Jenewah* gave the largest number of cuts, the actual yield was the highest for *surwala*; the yield of *Bhanjura* being a close second. During the same period, amongst the cultivated grasses, in spite of its giving the same number of cuts as Guinea, the Napier grass proved to be the heaviest yielder. A comparison of yield as well as number of cuts obtained from indigenous and cultivated species would show that the best performer (*surwala*) amongst the former is barely half as good as the best (Napier) amongst the latter.

In order to present a clearer picture of the duration of supply of green cuts the data in Table II has been re-arranged in Table III (page 600) showing the number of cuts and yield obtained during pre-monsoon, monsoon and post-monsoon periods.

The data in Table III show that in the pre-monsoon period of first year's growth, *jenewah* and *kolukattai* gave double the number of cuts as compared to the other indigenous species, but the total yield of *jenewah* and the yield per cut of *kolukattai* were definitely lower than those of the other grasses obtained in a single cut. The pre-monsoon productions, in the case of all the indigenous grasses were considerably reduced in the second year, and from the third year onward it became *nil*. In the post-monsoon period, three out of five indigenous grasses gave a cut each in the first year. Except for *jenewah* and Golden Crown, the post-monsoon production improved considerably in the second year. In subsequent years, although the grasses gave a cut each in the post-monsoon period the yields were very poor.

The pre-monsoon production of the cultivated grasses was heaviest in the first year. In the following two years, the production was significantly reduced and became relatively negligible in the last year of observation. Of the three species, Napier grass gave the highest yield in the pre-monsoon period. The post-monsoon production of all the cultivated grasses showed the peak in the second year but recorded a steep fall in the year following. The position was found to be further worsened in the final year. Napier grass again, amongst the cultivated species, gave the highest yield in the post-monsoon period. A comparison of yield figures of indigenous and cultivated grasses at pre and post-monsoon periods during the four years of observation would show that in quantitative production outside the growing season, the cultivated grasses excel the indigenous species.

The results of the present investigation lead to the conclusion that cultivated exotic grasses, specially Napier and Guinea, are definitely superior producers as compared to the indigenous varieties. When the superior productive capacity of cultivated exotics is established, the question arises why the growing of indigenous species should be considered at all in the *barani* lands to be opened in the future.

In chalking out the policy for grass production, it will be necessary to consider aspects other than relative yield. Two such important considerations would be (*a*) the cost, labour and organization involved in the production and (*b*) the number of effective channels of disposal of the produce. In the case of cultivated grasses, propagation will be both laborious and costly as it involves multiplications by roots, whereas indigenous grasses can be grown simply by broadcasting the seeds. In the same way, since cultivated grasses grow in thick clumps and no mechanical contrivance can be used in cutting, there will be greater involvement of labour and organization to secure the harvest by hand. Normally, cut grasses of cultivated species are used either as green fodder or as conserved silage. The indigenous grasses, on the other hand, can be utilized in four different ways, *viz.*, as pasture, green fodder, silage and hay. Because of the variety of ways by which the indigenous grasses can be utilized, there should never be any complication in controlling their timely disposal. These advantages in production and effective disposal should greatly compensate the relatively lower yield of the indigenous grasses. In the future programme of grass production in *barani* lands therefore, indigenous species will always hold their own when the question of selection of the type arises.

TABLE II

Yield of grasses in lb. (on fresh basis) per 1/20th of an acre

Name of the grass	Date of sowing	Interval before 1st cut		Yearly performance														
				1940			1941			1942			1943			1944		
		Months	Days	No. of cuts	Total yield	Average yield per cut	No. of cuts	Total yield	Average yield per cut	No. of cuts	Total yield	Average yield per cut	No. of cuts	Total yield	Average yield per cut	No. of cuts	Total yield	Average yield per cut
							Indigenous grasses											
Jenewah ..	11-7-1940	4	17	1	357	—	6	1851	308	4	847	212	3	1015	338	3	547	182
Golden Crown	11-7-1940	4	17	1	448	—	4	2052	513	3	1782	594	2	1844	922	3	480	160
Kolukattai ..	18-8-1940	3	10	1	376	—	4	1480	370	4	2076	519	2	1155	578	3	495	165
Bhanjura ..	31-8-1940	9	12	*nil*	—	—	5	1747	349	3	2748	916	3	1557	519	3	1175	392
Surwala ..	2-9-1940	9	10	*nil*	—	—	3	1231	410	3	3652	1217	3	2371	790	3	1389	463
							Cultivated grasses											
Rhodes ..	11-7-1940	4	17	1	546	—	5	2602	520	4	2142	535	3	1831	610	3	720	240
Guinea ..	14-7-1940	3	8	1	1208	—	6	3312	552	3	3615	1205	3	1961	654	3	955	318
Napier ..	14-7-1940	3	7	1	1160	—	6	7216	1203	3	4861	1620	3	4357	1452	3	2030	677

TABLE III

Yield of grasses in lb. (on fresh basis)

Performance in successive years

Name of the grass	1941						1942						1943						1944					
	Pre-monsoon		Monsoon		Post-monsoon		Pre-monsoon		Monsoon		Post-monsoon		Pre-monsoon		Monsoon		Post-monsoon		Pre-monsoon		Monsoon		Post-monsoon	
	No. of cuts	Total yield	No. of cuts	Total yield	No. of cuts	Total yield	No. of cuts	Total yield	No. of cuts	Total yield	No. of cuts	Total yield	No. of cuts	Total yield	No. of cuts	Total yield	No. of cuts	Total yield	No. of cuts	Total yield	No. of cuts	Total yield	No. of cuts	Total yield
												Indigenous	*grasses*											
Jenewah ..	2	289	3	1254	1	308	1	107	2	540	1	200	*nil*	*nil*	2	897	1	118	*nil*	*nil*	2	435	1	112
Golden Crown ..	1	900	2	750	1	402	1	412	1	1170	1	200	,,	,,	1	1760	1	84	,,	,,	2	400	1	80
Kolukattai ..	2	665	2	815	*nil*	*nil*	2	371	1	840	1	865	,,	,,	1	1013	1	142	,,	,,	2	355	1	140
Bhanjura ..	1	366	3	1181	1	200	1	253	1	1232	1	1263	,,	,,	2	1359	1	198	,,	,,	2	1050	1	125
Surwala ..	1	465	2	766	*nil*	*nil*	1	274	1	1824	1	1554	,,	,,	2	2266	1	185	,,	,,	2	1334	1	55
												Cultivated	*grasses*											
Rhodes ..	1	1050	3	1139	1	413	2	741	1	720	1	680	1	526	1	1097	1	208	,,	,,	2	580	1	140
Guinea	2	1258	3	1401	1	653	1	283	1	1848	1	1484	1	267	1	1405	1	289	1	230	1	450	1	275
Napier ..	2	2090	3	4226	1	900	1	230	1	2750	1	1831	1	1160	1	2747	1	450	1	330	1	1420	1	280

—*Indian Farming*, Vol. VII, No. 4, April 1946.

SCIENCE AIDS AUSTRALIAN TIMBER INDUSTRY

By Charles Lynch

High standards of treatment of the products of the Commonwealth of Australia's forest areas have been established by scientists and research workers.

Special seasoning of timbers, manufacture of paper from hardwoods, and impregnating and preservation methods are some of the directions in which research has increased the value and multiplied the uses of the wide variety of Australian-grown timber.

Australia possesses in its great variety of timber many woods which are of a considerable commercial value. Some are unexcelled in special qualities which make them suitable for specific uses. Scientific development of forestry products will lead to less reliance upon imported timbers, and new uses are being found for local species which formerly were neglected.

The research work is being undertaken principally by the Forest Products Division of the Council for Scientific and Industrial Research.

Australia's total output of sawn native timber for the year ended 1942-1943 was 855,728,000 super feet.

The various States have all given special attention to forestry schemes, and the State of Victoria has an ambitious plan to embark on intensive forest preservation which will cost between Rs. 21,71,66,700 and Rs. 32,12,54,000.

This long-range scheme will take 20 years to complete, and will open up forest areas estimated to yield 6,000,000,000 super feet of merchantable timber worth approximately Rs. 64,25,00,000.

Seasoning of timber in Australia is of a very high standard. The Forest Products Division of C.S. and I.R. has investigated the seasoning properties by both air and kiln treatment methods.

Information on this vital aspect of timber production has been distributed by means of correspondence course, special classes, trade circulars, and individual advice. Plans and specifications for treatment kilns have been supplied in large numbers, and kiln operators have been trained in modern methods.

During World War II, the kiln seasoning knowledge disseminated by the Council was of the utmost value in meeting emergency demands for suitable building material.

Paper-Making

In the manufacture of paper from local forest products, it was left to the Australian research worker to demonstrate that it was not so much the length of the fibre that was important in manufacture as the relationship of the fibre length to the fibre thickness. This discovery immediately made practicable the utilisation of Australian hardwoods for paper-making, and dispelled the idea that softwoods, because of their long fibres, were alone suited for paper manufacture. Thus it was found that the eucalypt timbers which abound in Australia could be used for paper-making. This discovery led to the establishment of three large pulp and paper mills costing several millions of pounds, with a yearly production value of over Rs. 10,70,83,333-5-4.

Tannin extracts from Australian trees represent another important product developed by local research. Not only has the local market been supplied, but Australia has been able to export considerable quantities of high quality material.

Investigational work on the timber used by departments and public bodies such as the Postmaster-General's Department, the Railway Department, Electric Supply authorities and Harbor Trusts, has resulted in a saving to these bodies of over Rs. 53,54,165 a year. The work undertaken successfully covers the preservation of the timber used in posts, poles and rail sleepers.

When military requirements called for a tremendous development of such buildings as hangars and large stores in the northern areas of Australia, they were constructed in quick time and with the minimum consumption of timber.

Complete instructions for designers as to the use of the timber were issued to both Australian and American engineers, and buildings sprouted up like mushrooms.

As these buildings were erected further north, the research workers found themselves confronted with problems of protection against rot, termite attack and tropical conditions. Studies of timber-attacking fungi and insects and preventive methods enabled the Forest Products Division to devise means of keeping the vital buildings safe from the activities of the destructive pests.

Applied scientific methods of seasoning enabled the output of rifles to be stepped up. Correct seasoning of wood used in stocks reduced rejections from 17 per cent. to less than 2 per cent. at a time when losses could ill be afforded.

Use of selected Australian timbers for aircraft was one of the direct results of war-time industry. Their uses are being extended in this direction.

NEW FIELD

Production of improved wood, compressed and impregnated, has latterly opened up a new field for Australian timbers, and the Division has also manufactured variable density wooden airscrew blades which have stood up to test. The improved wood blade is lighter than the metal blade, and has other advantages.

Extensive work on veneer and glueing has also been carried out. Standards for the glueing of plywood have been raised, and a process developed for preventing borer attack in certain veneers. Folded boats, pontoons and barges were produced from Australian plywood in large numbers during the war.

As the result of research many timbers previously believed worthless have found valuable uses. A plywood industry has been established in Western Australia using *karri* as a raw material.

Activities of the Council for Scientific and Industrial Research in the future will be directed towards the more complete utilisation of timber. It is estimated that nearly 90 per cent. waste now occurs in the forest, sawmill and manufacturing industries.

Durable timbers are becoming increasingly scarce, and less durable timbers must be given preservative treatment to meet the demand for posts, poles and sleepers. In the elimination of waste the attention of research experts is now being directed to Australian sawmills, where the installation of equipment to meet the peculiar conditions of the industry and organisation of production generally, are factors that will enhance the value of milling and general treatment of timbers.

—*Release No. P/378, of the Public Relations Officer, Australian High Commissioner's Office, New Delhi.*

LESSONS FROM THE FARM FORESTRY PROJECTS

BY JOHN F. PRESTON

(In charge of the Forestry Division, Soil Conservation Service, Washington, D. C.)

Farm forestry demonstration projects were handled by the Soil Conservation Service for the six fiscal years from 1940 through 1945. This article is a report of that stewardship.

The soil Conservation Service is an agricultural agency. It is engaged in promoting a soil conservation program for farm and ranch. It is the leader of the nation-wide fight to save basic agricultural soil resources for the American people. Trees and forests fit into its work because they are useful conservation tools. Planted trees can restore to productivity eroded areas lost to most other useful purposes. Existing woodland, if protected and managed, is the best known protection to the soil. It would be futile for the Soil Conservation Service to attempt to plant trees on land unfit for other uses and at the same time fail to attempt to get farmers to take care of existing woodlands on lands best suited to woods. Failure to do this would create new hazards. The planting and woodland management are therefore integral parts of soil conservation. Farm forestry is part of the work of the Soil Conservation Service.

The message about trees and how they fit into farming to conserve soil and to help farmers make a better living is carried by soil conservationists. This is part of the land-use adjustment involved in farm planning. Assistance in the management of all crops

on the farm so as to use each parcel of land in accordance with its needs and adaptabilities is the next logical step in getting conservation practised on the ground. Assistance in the techniques of tree planting and woodland management constitutes the forestry part of the work of the Soil Conservation Service. A staff of trained foresters, in the Washington and regional offices and in the field, is maintained to instruct and help farm planners with this job.

Historical Background

The Soil Conservation Service started in 1935. It conducted demonstration projects throughout the nation showing ways of controlling soil erosion and at the same time helping farmers to make a better living. Farm forestry was part of this program. The soil conservation district movement grew out of those demonstration projects, and now the Service is assisting 1,381 districts scattered throughout 45 States.

On May 18, 1937, the Co-operative Farm Forestry Act, familiarly known as the Norris-Doxey Act, was passed by Congress. This act authorized an enlargement of the Department of Agriculture's program of assistance to farmers in farm forestry. Prior to the passage of this act, the only special federal funds available for this activity were those provided by Sections 4 and 5 of the Clarke-McNary Act of June 7, 1924, under which appropriations were limited to not more than $100,000 annually. From that time until the fiscal year 1940, when an appropriation of $300,000 became available under the Norris-Doxey Act, the Department's special forestry assistance to farmers on a nation-wide basis consisted of two activities—(1) assistance to States through the Forest Service in growing and distribution of tree planting stock, and (2) the extension forestry program of the Extension Service.

On October 6, 1938, the Secretary of Agriculture assigned part of the responsibility for activities under the Norris-Doxey Act to the Soil Conservation Service. Drawing on its experience with demonstration projects to awaken farmers to the need for erosion control, the Soil Conservation Service proposed, and the Department accepted, the establishment of intensive farm forestry projects intended to determine just what forestry could contribute to farm economy. The projects were planned for a period of 20 years or longer with careful records by each co-operator of all his forestry activities. The Soil Conservation Service was assigned responsibility for what came to be known as "farm forestry projects" and the Forest Service for "forest farming projects." The distinction between the two kinds actually proved to be much more theoretical than real. In round numbers during the 6-year period from the fiscal year 1940 to the close of the fiscal year 1945 there were 45 farm forestry projects and about 10 forest farming projects. Leaflet No. 208 of the Department of Agriculture, "Intensive Projects Under the Co operative Farm Forestry Act," indicates the objectives and purposes of the Department in the administration of farm forestry projects. A careful but simple book-keeping system was used on each project for recording the woodland activities of each co-operator.

Of the 45 projects directed by the Soil Conservation Service, 17 were financed 50-50 by the states and federal government and were administered by the states under the general guidance of the Soil Conservation Service. The other 28 were financed almost entirely with federal funds and were administered directly by the Soil Conservation Service. All projects were operated in co-operation with the state and extension foresters.

On July 1, 1945, the Secretary of Agriculture transferred the farm forestry projects under the Norris-Doxey Act from the Soil Conservation Service to the Forest Service. This action does not affect the forestry activities of the Soil Conservation Service which are conducted as an integral part of its farm conservation program. These activities include the preparation of a woodland program as part of each individual farm plan, and technical forestry assistance to farmers to help them realize the values inherent in a woodland cover. Unless these inherent values are translated into income and other tangible benefits, woodland cover will not long be maintained and soil conservation objectives will not be achieved.

This article constitutes a partial report by the Soil Conservation Service of its 6-year stewardship of the farm forestry projects. A more complete report is available to those who are interested.

CONCLUSIONS

The lessons learned from administration of the farm forestry projects can be classed as answers to the general question, "What does it take to get farmers sufficiently interested in forestry to undertake a farm woodland enterprise?" I have put down ten answers to that question.

1. There must be an enterprising and resourceful farm forester who understands farmer psychology and uses every means at his disposal to locate farmers who are willing to co-operate on a woodland development and management program. His most important means of interesting farmers are, of course, the cash benefits, which the farmers will receive as a result of their forestry activities. Other incentives are wildlife, general beautification of the farm, the protection afforded to crops and farmsteads from wind, and the general indirect benefits that woodlands afford. In some cases the farm foresters have worked hard over a 2-year period in order to get as many as 20 or 25 farmers who were willing to co-operate on the basis set up by the Department. Out of this number perhaps only 10 or 12 actually co-operated to the extent of supplying the needed records.

2. The farm forester must have the help of other agriculturists in his campaign to get acceptance by farmers of a farm woodland enterprise. In most cases he needs protection of the woodlands from livestock. This means that open or brushy pastures must be made more productive in order to provide better feed for livestock and to replace the poor forage that formerly came from woodland grazing. He needs land-use adjustments on the farm in order to get a stable base for farm forestry. This includes use of lands for reforestation and a dedication of lands now in woods to forestry purposes. There is little use to attempt forestry practices on a woodland which may soon be cleared for cultivated crops.

The farm forester also needs farm labor for work in the woods. The agriculturists can help here, for this is part of farm planning. Furthermore, he needs labor on an annual basis because the only forestry that is going to be helpful in farm economy is the kind which utilizes farm labor and produces wood as a farm crop. Stumpage sales doubtless have their place, but in a permanent farm forestry program stumpage sales must play a smaller and smaller part. Lastly, the farmer forester needs the help of other agriculturists in getting the farmer to think about growing wood as a farm crop. This idea is so foreign to farmer thinking and philosophy, that the forester by the very nature of his work and training is handicapped in getting acceptance of such an idea.

3. There must be markets for the sale of surplus products. As Colonel Graves says in his report to F.A.O., "Forest management and wood utilization are two sides of the same coin." Finding a market for the wood-products for sale is just as much a part of the forestry job as selecting trees for cutting. Therefore, the farm forester has found it necessary and helpful to work with buyers and users of wood, seeking their co-operation in buying wood on a basis which permits farmers to operate in their small woodlands. Most of the farm foresters were fairly successful in this effort. Co-operatives were developed on projects in Florida, North Dakota, Kansas, Minnesota, and a few other states. Experience indicates that greater development along this line is necessary to the successful marketing of farm wood products. The most important market, however, is the home farm. The market for fence posts, lumber, poles, and fuel which are needed on the farm business takes a large part of the output of most farm woodland enterprises. Few farmers take full advantage of this market to develop their woodland growing stocks.

4. New tools and equipment: Not enough progress was made in this field, but surprising results were obtained where the farm forester really worked at the job of finding tools and equipment which would help farmers in carrying on woodland operations. Worth mentioning are the introduction of the Sandvik saw and in some cases chain saws. One farm forester reported 30 of the latter in use on his project. Other machines were the splitting guns, mechanical splitters, and tree-planting machines. The use of poison is on the increase in killing undesirable trees. There is still great need for the adaptation of farm tractors in the job of skidding and loading logs and other forest products. A tree planting machine is also needed for use on steep and brushy slopes.

Soil conservation districts have proved immensely useful in developing sentiment in favour of farm forestry, as well as in the more

prosaic task of owning and renting heavy equipment and machinery to facilitate the handling of forest products and the planting of trees. Portable mills of various types have been used. The story in the September issue of *American Forests*, "The Jeep Sawmill Moves West," is the direct result of the activities of a farm forester who is one of the firm of Farm Foresters, Incorporated, now engaged in practical help to farmers and other timberlandowners through making available to them suitable logging and sawmilling equipment to market their surplus products. One encouraging result of the work is the increasing number of farm foresters who have undertaken consulting work with farmers as their prospective clientele.

5. A farm forestry program does not run along on its own momentum. It takes longer than one or two years to get a farmer to the point where he will continue to practice the kind of forestry the farm forester has been teaching him. He seems to require rather continuous follow-up work by the farm forester. Whether in a 20-year project the farmer will require detailed assistance every year remains to be seen, but certainly the first 5 years he needs rather frequent help if the farm woodland enterprise is to be a success.

6. Considerable community momentum is gained from the success of the co-operators who are active. This is simply the old story of success creating more success. On projects where it was extremely difficult to get co-operators the first two years there were often more applicants in the third year than could be served. So while progress is at first slow, as the evidence of success accumulates the rate of improvement will be greatly stepped up.

7. It has become more and more clear to the Soil Conservation Service that farm forestry is a farm problem and that it must be approached from that angle if it is to be a permanent asset to the farm. Unless forestry is built into the farm program it will not last long. Forestry activities must become habitual, not spasmodic. The Soil Conservation Service insisted that every Type I cooperator in an intensive farm forestry project should have a forestry plan which was part of a farm plan, so that forestry would be properly related to all other farm activities. Experience has proved that this philosophy is sound. Farmers get value out of their woodland enterprise in direct proportion to the time and energy they put in. This, of course, is true not only in forestry but in many other activities. I quote from a farm forester in Michigan:

"Examination of woodland records reveals that woodland owners with the highest income spent over four hours per acre per year in their woodlands and those with the low income spent about one-half hour per acre per year in their woodlands. Further study shows that the average farmers have about 120 to 140 hours each year which are available for woodland work. Whenever they miss a year they do not have the opportunity to make it up the following year and consequently do not secure an income to offset taxes and interest for that year. Taxes and interest on capital investment accumulate whether or not the woodland is worked. It is evident that if the farm woodlands are to be a paying proposition they must be worked on a yearly basis.

"Farmers spending one year out of every three or four in their woodland invariably lost money, while those working in their woodland every winter made an income directly in proportion to the time spent."

TABLE 1.—RETURNS FROM FARM WOODLANDS, 1943-1945

Fiscal year	Number of farms	Acreage of farm woodlands under mgt.	Net income: Total	Net income: Per farm	Net income: Per acre	Products cut: Total reduced to Bd. ft.	Products cut: Total reduced to Cords	Products cut: Per acre Bd. ft.	Products cut: Per acre Cords
1943	148	15,506	$38,371	$260	$2.47	3,112,880	7,906	200	.51
1944	509	49,155	162,943	320	3.31	9,694,355	26,694	197	.54
1945	441	44,126	213,941	485	4.85	19,910,281	50,059	451	1.12

8. Fine-spun timber management plans have not proved useful up to this point in the administration of the intensive farm forestry projects or in the general farm forestry program conducted by the Soil Conservation Service. The cruising of timber on anything but a spot basis is not necessary, and growth studies are largely theoretical and have little bearing on success in the initial stages of farm forestry work. These things will undoubtedly have

their place as further progress is made, but certainly in the first 5 years there is little need for them. This is not true in the case of a farmer who wants to sell stumpage and practice commercial forestry, but such a co-operator contributes very little to the economic research involved on farm forestry projects. The farm forester starts on a program of meeting the obvious need. The woods requires an improvement cutting and offers an opportunity for the utilization of farm labor. He ties these two things together and starts cutting on a conservative silvicultural basis directed at building up the growing stock and getting the farmer in the habit of working in his woods and of getting an annual income from the woodland.

9. The records. To get accurate records of the income and outgo on a farm woodland enterprise has proved to be very difficult. Nonetheless, it is worth while and we must have the records if we are going to prove what part forestry can contribute to farm economy. Probably the most expensive part of the farm forestry projects was keeping the records of activities in the woodland of individual farmers. At best, no high degree of accuracy was attained, but by frequent trips to co-operators' farms reasonably satisfactory records were secured.

Table 1 on the previous page, gives some records from a few co-operators for each of the last three fiscal years. The figures show increasing revenue per farm and per acre as would be expected during the war period. In spite of our best efforts most of the net income still represents stumpage scales. The effort to get farmers to sell processed products, instead of stumpage, is not without its reward, but so far most of the income is from stumpage sales. Obviously, the best showing will be made when the former is the accepted practice. On individual farms the highest income per acre is made by farmers who process and sell forest products and by those who make woods cutting an annual job.

10. Farm forestry thus far has not proved to be a highly technical job. It is a common-sense and simple forestry activity. Farmers who are supposed to take over and apply the techniques have neither time nor ability to acquire a high degree of skill. They can learn the art if not the science. They can get the feel of the axe as a silvicultural tool and that is enough. By and by they will not only become proficient in the art but they may even become skilled in the science.

—*Journal of Forestry*, Vol. 44, No. 1, January, 1946.